Chapter 7

R645-301-700 Hydrology

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R645-301-710 Introduction

This chapter discusses existing hydrologic resources and potential impacts resulting from existing and proposed mining and reclamation operations. Hydrologic performance standards, design criteria, plans along with methods and calculations and reclamations are discussed.

Cross sections, maps and plans required to be certified under these regulations have been prepared by or under the direction of a qualified, registered, professional engineer whose stamp and signature can be found on the individual document in question.

R645-301-720 Environmental Description

R645-301-721 General Requirements

Existing, premining hydrologic resources within the permit and adjacent areas that may be affected or impacted by proposed coal mining and reclamation operations are defined and discussed in the following outline.

R645-301-722 Cross-Sections and Maps

722.100 Subsurface Water

Plate 7-4A shows the potentiometric surface for Spring Canyon. Plates 7-10A and 7-10B show the mine water surveys for the Blind Canyon Seam and the Hiawatha Seam respectively.

722.200 Surface Water

Plate 7-5 shows the affected watersheds. Plates 7-1 show the surface hydrology.

722.300 Water Monitoring Stations

Plate 7-4 shows the location of all water monitoring stations.

722.500 Slope Measurements or Contour Maps

Plates 7-1 show the existing land surface configuration.

R645-301-723 Sampling and Analysis

All water quality analyses performed to meet the requirements of this chapter will be conducted according to the methodology in the current edition of *Standard Methods for the Examination of Water and Wastewater* or the methodology in 40 CFR Parts 136 and 434. All samples will be analyzed by certified labs.

R645-301-724 Baseline Information

724.100 Groundwater Information

The scope of this study consisted of an investigation of the groundwater hydrology of the Co-Op Mining Company (Co-Op) permit area (Plate 2-1), based on the Utah Division of Oil, Gas and Mining (DOGM) permit application guidelines. Information on regional and site groundwater hydrology and groundwater resources was compiled from:

1. Literature Review. Published and unpublished information on the geology and hydrology of the Bear Creek area, including U.S. Geological Survey investigative reports and personal communications, data from prior mining and engineering investigations in the general area and groundwater and engineering data obtained by Co-Op, were reviewed.

2. <u>Site investigations</u>. Water quality and quantity data was collected from springs, surface seeps, mine roof seeps and sumps and groundwater discharge into drill holes in the mine area, supplemented by published regional data. Stratigraphic sections, aquifer characteristics and the affect of geologic structure on the groundwater regime in the permit area were made on the basis of drill hole logs, drilled for this study, detailed interpretation of geophysical well logs, conducted for this study, and on geologic field mapping.

An outline for the groundwater-monitoring program for the Mine Plan area was then made based on the results of our study, by assessing the impact of mining on the local and regional groundwater hydrology. See Appendix 7-L for further information.

<u>Regional Groundwater Hydrology</u>

The occurrence, availability and movement of groundwater in the Mine Plan and surrounding areas are controlled by structural, stratigraphic and topographic factors, with snow-melt the source for most, if not all, of the groundwater in the Cottonwood-Huntington area (Danielson, et. al., U.S.G.S., 1981). According to this report, available data for the study area, which includes the permit area, indicate that the Star Point sandstone and the lower part of the Blackhawk formation, are an extensive aquifer, with many of the large springs in the Cottonwood-Huntington area, including Bear Springs, issuing from fault displacements of this aquifer. Our studies indicate, however, that within the areas of in-mine wells DH-1A, DH-2 and DH-3, separate and distinct aquifers exist in the Spring Canyon, Storrs, and Panther tongues of the Star Point Sandstone (See Appendix 7-N), rather than one single aquifer within the Star Point sandstone and Blackhawk formation.

A detailed hydrogeologic evaluation of the Star Point aquifers is included in Appendix 7-N. General observations concerning the groundwater hydrology and geology of the permit area and surrounding areas are presented in Appendix 7-J.

Existing Groundwater Resources

Groundwater occurs under both unconfined and confined conditions in the permit area. The unconfined conditions occur as local perched zones within bedrock and as saturated zones in shallow alluvial deposits along the main drainage bottoms and in the surficial soil mantle, and are expressed as local seeps. Confined conditions occur at depth and are either fault controlled, with the faults serving as channels and/or barriers to groundwater flow, or controlled by an aquifer being overlain by an impermeable layer.

Data obtained from our investigations encountered perched water within the lower portion of the Blackhawk formation. Mine roof seeps, however, do not exhibit seasonal variation or response to precipitation and consist of persistent, relatively unvarying seeps or infiltrations. The source of these seeps is apparently from larger, overlying perched zones, exposed sufficiently by mining activities to allow slow drainage or possibly areas of joint systems, sufficiently interconnected to provide a larger source area.

Drillhole data also indicated that three separate aquifers exist within the Star Point sandstone tongues. The investigation of these aquifers is presented in Appendix 7-N.

Fracture-enhanced permeability allows water to pass vertically through strata, which would normally impede flow. Depending on the extent to which the fractures are interconnected, vertical groundwater flow can be limited to a short distance, or it can extend to the regional water table. Joint systems at the surface exhibit enlargement by weathering but, based on observations within the mine, are expected to be generally closed or possibly non-existent with depth. Only minor, localized diversion of flow within the mine is expected to take place through the joint or fracture systems with no significant affect on regional flow patterns. The degree of rock fracturing in the Bear Canyon seam and overlying mine roof rock is relatively low, based on visual observations of the rock quality within the mine and general lack of mine roof over-break. Outcrop examinations indicate the joint systems are not extensively interconnected.

Springs in the area, specifically Big Bear Springs, located next to the southeast corner of the permit area, are the most significant water resource for the area. Mining activities have not affected the volume or quality of the flow of these springs for the reasons discussed in the following paragraph (See Appendix 7-J and Appendix 7-N).

Flows for the two major springs adjacent to the permit area, Big Bear Spring and Birch Spring, as well as flows for two additional springs, Little Bear Spring and Tie Fork Spring, have been included in Appendix 7N-D. Annual plots of the flows are shown in Appendix 7N-E. Plots of the flow from Big Bear Spring show that peak flows during the period of 1980 through 1986 occurred about one month later than peak flows at the Huntington gauging station. In the 1987-1988 water year, the lag period between peaks in the stream and spring discharge is approximately two months. This increase in lag time is attributed to a combination of lower precipitation accumulations and shorter snowmelt period (See Appendix 7-N, section 2.7.3). Because the period of record flows for Birch Spring is limited (Appendix 7-N, section 2.7.4), a comparison of flows to Huntington Creek prior to 1990 cannot be made.

Aquifer Characteristics

Appendix 7-J, Section 4.0 discusses the groundwater aquifer characteristics in detail. Plate 7-4 identifies the locations of springs and water monitoring points within and adjacent to the Permit Area. A generalized stratigraphic section of the geologic units is shown in Appendix 7-J, Figure 5. Plate 7J-1 and 7J-2 show hyrologic cross-sections, which illustrate the projected potentiometric surfaces within the permit areas.

Field measurements and drill hole data indicate the regional strike, dip and bedding thicknesses are quite uniform within the mine permit area. Four drillholes were drilled immediately North of the permit area and investigated by Savage Energy Services Corporation (T-1, 2, 4, 5). Three additional drill holes were drilled by Co-Op in the same area (SDH-1, 2, 3). Three holes were also drilled north of Wild Horse Ridge by Cyprus/Plateau (MW-114,116,117). Lithology and water level information for all of these holes except MW-114 is shown on Plate 7-9. Projections of bed elevations obtained from this drill hole data were in close agreement with the equivalent bed elevations at the site, at a regional dip of approximately two degrees south.

Evidence of low displacement (5 to 10 ft) faulting was observed within the mine in several locations, as well as in many locations on the surface. Some of these low displacement faults exist in the area around Birch Springs. Large displacement faulting (over 150 ft) is evident by the Bear Creek fault or fault zone at the east margin of the Mine Plan area (Plate 7-4), and the Blind Canyon fault, which bounds the western edge of the mine. The faults can significantly alter the groundwater flow pattern of the area. A well developed, near vertical joint system is evident in outcrops. Regional and site bedding dips are essentially south (1 to 2 degrees), with an easterly component in the permit area.

The stratigraphic section is summarized below, beginning with the Star Point Sandstone at the base, up through the North Horn formation, the uppermost unit exposed in the Mine Plan area:

1. Star Point Sandstone. Thickness ≈ 350 ft; Consists of three tongues of sandstone interbedded with two tongues of the Mancos Shale. Contacts with the shale tongues and with the underlying Mancos shale is gradational. A detailed geologic and hydrologic description of each sandstone bed is described in Appendix 7-N, Section 2.5.

2. Blackhawk formation. Thickness ≈ 825 ft; cyclicly interbedded, 65 pct sandstones, 20 pct siltstones and 15pct mudstones (volume percentages determined by geophysical well log analysis for this study). Sandstones are of low to moderate porosity and generally laterally discontinuous. The lower 100 ft. contains the commercial coal seams. Star Point-Black hawk contact is conformable.

3. Castle Gate Sandstone (lower member of Price River formation). Thickness ≈ 175 ft; fine to medium grained, thick bedded fluvial sandstone with moderate porosity (.22 calculated from geophysical well log data of drill hole T-5) and common solution cavities. Castle Gate-Black hawk contact is conformable.

4. Price River (upper member). Thickness ≈ 650 ft; thick bedded to massive, fine to medium grained sandstone with low to locally moderate porosity, 40-50% mudstone-siltstone interbeds. Price River-Castle Gate contact is conformable.

5. North Horn formation. Thickness ≈ 1500 ft; predominantly shales with common lenses and irregular beds of fine to occasional coarse sandstone, occasional erratic conglomerate lenses and minor thin limestones. North Horn-Price River contact is poorly defined (conformable).

Of the entire section above, the Castlegate sandstone, with few local exceptions, is the most porous, with a porosity of .22, calculated from geophysical density logs conducted for our study. From personal communications (W. Hull, Northwest Energy), zones of voids or open fractures were common within the formation on drilling holes T-1, 2, 4 and 5 and SDH holes 1,2 and 3 and extensive to total drill fluid loss characterizes the formation in the general area. Depths to the drill fluid levels in the above holes ranged from 125 ft (in a bridged hole) to 400 ft below the Castlegate base within a short period after drilling. These occurrences indicate that no significant water was encountered in the formation and that secondary permeability due to void and joints or fractures may occur in a near vertical direction.

Porosity of the remainder of the section, with local exceptions of clean, fine to medium grained sandstones, ranges from generally low for the fine silty sandstones predominant in the section to very low or impermeable for the remaining siltstone-shale sequence.

Aquifer Storage

Quantitative data or published estimates are not available on the amount of water stored in the rock units in the permit area. The Castlegate Sandstone does not appear to serve as even a partially saturated aquifer, apparent from the lack of springs flowing from the formation within the permit area. The Star Point sandstone contains three separate aquifers, as indicated by our in-mine drillholes. All three of these aquifers are only partially saturated in the southern portion of the permit area, and appear to be fully saturated in the northern portion of the permit area. Aquifer piezometric surfaces are shown in Appendix 7-N, Figure 2-2. The Blackhawk formation consists of approximately 30 pct of generally discontinuous sandstone layers, with some of these occurring as perched, saturated to partially saturated zones. About one-third of the Blackhawk has been removed by drainage development in the permit area, leaving approximately 625 acres of this formation, in plan view, within the permit boundaries.

Assuming dry to increasing saturation with depth of these sandstone lenses and an average 825 ft thickness for the Blackhawk and, assuming relatively impervious, remaining, intervening silt to mudstone layers, a storage coefficient of 0.10 is assumed for the Blackhawk. This results in a storage of roughly 55,000 acre-ft within the Blackhawk formation in the permit area. The initial interception of groundwater, expressed as roof seeps, by the mine workings was approximately 3-½ acre ft/yr.

In 1989, a significant amount of water was encountered in the 1st North Section of the #1 Mine Blind Canyon Seam, expressed as roof drips and flowing from roof fractures. Mining eventually encountered the apparent source of this water, a significant channel sandstone, which traverses East-West along the North end of the #1 Mine. The exact dimensions and configuration of this channel is unknown. Isotopic dating of the water in this aquifer has indicated the water to be approximately 1,000 years old. It is anticipated that Co-Op will eventually dewater this aquifer. Surface and groundwater monitoring has indicated no hydraulic connection between this aquifer and any springs in the permit area. To date, no impacts as a result of this dewatering have been observed in any of the springs within the permit area. Additional discussion on this channel is given in Appendix 7-J.

Isotopic dating of Big Bear Springs, as well as chemical analysis, has indicated that the spring is not hydrologically to the mine water or the channel aquifer. Monitoring of Big Bear Springs, as well as Birch Spring and the other springs within the permit area will continue in order to ensure that no impacts due to mining occur. A description of the isotopic and chemical data of the mine water and springs is shown in Appendix 7-J. In 1998, surface wells SDH-2 and SDH-3 were sampled for baseline parameters and for isotopic dating. This information is discussed in Appendix 7-J.

Hydrologic information from monitor wells MW-114, 116, and 117 indicate that the uppermost tongue of the star point sandstone is unsaturated under Wild Horse Ridge. A detailed discussion of this aquifer is given in Appendix 7-J.

Aquifer Recharge

Snow at the higher elevations provides the greatest source of groundwater recharge. Deuterium analyses of groundwater in the region indicate that most, if not all, groundwater is derived from snowmelt (Danielson et. al., 1981). The percentage of water derived from snowmelt, which recharges the groundwater system versus that which runs off to stream flow is controlled by the surface relief, the permeability of exposed strata, the depth of snow pack, and the rate of snowmelt. Published precipitation contours for the area indicate annual precipitation of 17 to 18 in./yr for the permit area.

Evapo-transpiration is estimated to be on the order of three to four inches annually (Danielson, et. al., 1981). Surface runoff, based on a mean site elevation of 8200 ft and on the generally deeply incised nature of much of the permit area and the predominance of south, east and west-facing slopes, is estimated to be 11 to 12 in./yr. These values correspond to estimates by others for the general area (Intermountain Consultants, 1977).

Up to three inches average annual precipitation is thus available for recharge for the 1140-acre permit area, resulting in an equivalent 285-acre ft/yr. The large proportion of outcrop versus total surface area of most of the permit area makes outcrop areas and drainage channel alluvium the principal recharge sources, with the soil mantle becoming increasingly important in the north part of the area.

Additional discussion on groundwater recharge is given in Appendix 7-J and 7-N, section 2.4.2.

Aquifer Water Quality

Results of baseline water sample analyses for the Bear Canyon fee area are presented in Tables 7.1, 7.2 and 7.3. The chemical characteristics of the ground and surface water in the permit area are quite uniform with the exception of higher suspended solids content in the surface water. It is noted that sulfate contents are lower in the Bear Springs samples while surface water (Bear Creek), in contact with an appreciable section of the Star Point Sandstone in its lower reaches, is relatively high in sulfate. Previous studies (Danielsen, et. al., 1981) indicate water derived from the Star Point aquifer is higher in sulfate than the overlying units. This is additional indication that the Bear Springs supply is not the Star Point-Blackhawk aquifer.

Baseline water quality data for the springs in and around Wild Horse Ridge and Federal Lease U-024316 are presented in Appendix 7-M. The majority of the springs identified flow from faults and joints in the North Horn and Price River formation. The chemical characteristics of these springs are similar to the other springs within the permit areas. Spring WHR-6 (SBC-14), which issues from the Star Point Sandstone (Spring Canyon Tongue), displays sample results for TDS consistently over 1500 mg/l. This is similar to the quality observed in Well SBC-3, and is typical of water quality from the Star Point Sandstone.

Appendix 7-M includes some water quality information for the McCadden Hollow springs around Lease U-024316 for 1991 and 1992 and information form springs in the Mohrland Area. All water quality information is also summarized in Appendix 7J-A, the PHC document.

Table 7-1 Water Quality and Flow Data, 1984, 1985

Sample/Date	TDS	TSS	Carbonate (as $CaCO_3$)	Alkalinity (as $CaCO_3$)	Ca	Mg	Fe (dis.)	Na	K	HCO_3	SO_4	Cl	Nitrate	pH	Flow (gpm)
Sump Su-3 (10/84)	300	5	0	285.5	36	36.0	0.19	29.2	4.43	234	55	8.0	0.06	7.3	---
Su-3 Roof Drip (10/84)	380	17	0	383.1	60	38.4	0.12	19.2	3.65	314	40	2.0	0.03	7.3	3-5
SBC-1 Drips (2/85)	235	1	0	---	46	35.0	0.03	3.0	1.4	216	66	4.0	0.06	8.1	3-5
SBC-1 (10/84)	362	11	0	309.8	80	21.6	0.33	26.0	0.97	254	27	50.0	0.24	7.4	---
SBC-1 (11/84)	175	54	5	---	15	36.0	0.06	4.0	1.5	141	43	3.0	0.22	8.4	---
SBC-1 (12/84)	285	4	7	---	45	38.0	0.09	6.0	1.6	220	56	4.0	N/D	8.4	---
SBC-1 (1/85)	320	16	0	---	43	36.0	0.02	7.0	1.6	209	60	4.0	N/D	7.9	---
BC-1 (11/84)	415	1,620	0	---	43	57.0	4.8	8.0	3.5	200	161	4.0	0.47	8.1	26.0
BC-1 (12/84)	405	862	0	---	63	59.0	7.4	8.0	5.8	209	158	5.0	0.86	8.2	18.0
BC-1 (2/85)	485	1,170	0	---	56	60.0	5.13	10.0	4.1	221	191	5.0	0.48	8.0	9.6
BC-2 (10/84)	375	1,345	0	244.0	50	50.4	19.8	7.1	5.77	200	116	20.0	0.47	8.1	---
BC-2 (11/84)	160	2,190	0	---	22	25.0	4.14	4.0	2.3	95	64	N/D	3.41	8.3	26.8
BC-2 (12/84)	405	1,080	0	---	47	56.0	8.95	8.0	3.6	207	163	5.0	0.33	8.2	18.0
BC-2 (2/85)	505	154	0	---	56	62.0	0.92	11.0	4.3	223	202	5.0	0.46	8.3	18.7
Hole WM-C (2/85)	320	46	0	269	68	29.0	0.09	5.0	1.2	---	27	3.0	0.21	8.2	---
Bear Spring (10/84)	362	11	0	254	80	21.6	0.33	26.0	0.97	309.8	27	50.0	0.24	7.4	---
Birch Spring (10/84)	440	6	0	310	64	58.8	0.12	12.2	1.97	378.2	80	30.0	0.04	7.9	---

N/D = Not Detected
See Table 7.1-8 for description of water monitoring points.

Table 7-2 Water Quality and Flow Data, 1986 and 1987

Station: BC-1 (Lower Bear Creek)

Date	Flow gpm	Temp °C	pH	TDS	TSS	Tot. Alk.	Tot. Hard.	Ca	Mg	Fe (Tot.)	Na	K	HCO_3	SO_4	Cl	Nit.
1/15/86	F															
2/17/86	8	2	8.3													
3/20/86	30	2	8.2	540	1,736					23.3				222	5.0	0.44
4/23/86	27	2	8.3	468	5,100	212	375	51	60	13.6	10.0	4.5	253	181	7.3	0.48
5/13/86	49	3	8.2	304	4,540	217	274	52	35	60.0	8.9	2.2	265	74	4.8	0.20
6/15/86	61	4	8.0	438	504	194	265	56	31	9.1	9.0	3.0	237	86	4.0	0.24
7/23/86	62	4	8.1	320	512	184	282	37	46	1.55	7.7	2.9	224	107	4.3	0.26
8/12/86	58	8	8.0													
9/24/86	87	3	8.2													
10/01/86	55	3	8.2	420	110	207	324	70	36	3.91	2.0	0.0	253	122	2.0	0.25
11/22/86	F															
12/10/86	F															
1/05/87	F															
2/06/87	F															
3/26/87	30															
4/07/87	47	1	8.1	536	780	230	441	51	76	12.8	13.0	5.0	280	233	6.0	0.62
5/15/87	54															
6/17/87	59															
7/15/87	39															
8/26/87	42	12	8.4	420	193	200	346	40	60	3.37	9.0	4.0	241	149	2.0	0.67
9/24/87	36															
10/05/87	47	9	8.1	396	2.4	----	332	44	54	0.3	8.0	4.0	248	137	5.0	----
11/05/87	33															
12/04/87	F															

Station: BC-2 (Lower Bear Creek)

Date	Flow gpm	Temp °C	pH	TDS	TSS	Tot. Alk.	Tot. Hard.	Ca	Mg	Fe (Tot.)	Na	K	HCO_3	SO_4	Cl	Nit.
1/15/86	F															
2/17/86	26.2	2	7.9													
3/20/86	39.8	2	8.2	548	1,788					25.5				222	5.0	0.44
4/23/86	40	2	8.2	450	7,370	209	365	57	55	8.68	11.0	4.5	253	181	7.3	0.48
5/13/86	60	4	8.0	328	4,370	224	298	47	44	32.6	9.0	2.5	265	74	4.8	0.20
6/15/86	64	4	8.1	426	584	203	270	57	31	6.50	9.0	3.0	237	86	4.0	0.24
7/23/86	69	7	8.0	328	578	184	279	36	46	7.18	7.8	3.0	224	107	4.3	0.26
8/12/86	47	8	8.1	400	294	210	326	70	37	4.38	11.0	4.0	256	123	6.0	0.29
9/24/86	90	4	8.1													
10/01/86	62	3	8.2													
11/22/86	15	2	8.1													
12/10/86	F															
1/05/87	F															
2/06/87	F															
3/26/87	42.5															
4/07/87	52	1	8.1	560	980	227	455	49	81	18.1	14.0	5.0	276	255	7.0	0.75
5/15/87	67															
6/17/87	58															
7/15/87	47															
8/26/87	49	15	8.1	388	214	191	338	51	61	4.90	9.0	4.0	220	140	6.0	0.63
9/24/87	43															
10/05/87	51	10	8.0	404	54	----	336	53	50	0.34	8.0	4.0	251	139	5.0	----
11/05/87	43															
12/04/87	11.6															

F = frozen N/D = Not Detected units in mg/l unless noted otherwise

Station: BC-3 (Right Fork Bear Creek)

Date	Flow gpm	Date	Flow Gpm
1/15/86	D	7/23/86	D
2/17/86	D	8/12/86	D
3/20/86	D	9/24/86	D
4/23/86	D	10/01/86	D
5/13/86	D	11/22/86	D
6/15/86	D	12/10/86	D

Station: SBC-1* (Mine Water)

Date	Flow gpm	Temp °C	pH	TDS Alk.	TSS Hard.	Tot.	Tot. (Tot.)	Ca	Mg	Fe	Na	K	HCO_3	SO_4	Cl	Nit.
1/15/86	UK	4	8.0													
2/17/86	UK	6	8.1	280	2.0	232	292	51	40	0.04	4.0	3.0	232	49	3.0	0.09
3/20/86	UK	4	8.0	272	6.0	222	282	52	37	0.27	5.0	2.0	222	52	2.0	0.02
4/23/86	UK	3	8.3	266	21	203	244	45	32	0.05	5.3	1.7	241	48	3.3	0.12
5/13/86	UK	3	8.1	272	28	200	256	46	34	0.11	4.6	1.8	244	50	7.7	0.19
6/15/86	UK	8	6.0	382	2.0	254	280	42	43	0.05	5.0	1.0	310	30	4.0	0.39
7/23/86	UK	9	8.0	380	2.0	194	309	63	37	0.14	5.5	2.0	236	117	5.1	0.27
10/01/86	UK	4	8.0	364	----	215	296	62	35	0.05	6.0	2.0	262	85	6.0	0.09
1/05/87	UK	6	8.2	290	6.0	271	301	67	33	0.05	4.0	1.0	330	32	4.0	0.23
4/07/87	UK	3	8.0	306	1.0	275	305	42	44	0.3	5.0	1.0	335	28	4.0	1.21
8/26/87	UK	11	7.9	416	2.8	269	394	91	42	0.14	5.0	4.0	328	127	4.0	0.46

Station: SBC-2 (Portal Well)

Date	Flow gpm	Date	Flow Gpm
1/05/87	D	7/15/87	D
2/06/87	D	8/26/87	D
3/26/87		9/24/87	D
4/07/87	D	10/05/87	D
5/15/87	D	11/05/87	D
6/17/87	D	12/04/87	D

Station: SBC-3 (Right Fork Creek Well)

Date	Flow gpm	Date	Flow Gpm
1/05/87	D	7/15/87	D
2/06/87	D	8/26/87	D
3/26/87		9/24/87	D
4/07/87	D	10/05/87	D
5/15/87	D	11/05/87	D
6/17/87	D	12/04/87	D

D = dry UK = unknown units in mg/l unless noted otherwise
F = frozen N/D = Not detected *SBC-1 is the same monitoring point as SBC-7

Table 7-2 Water Quality and Flow Data, 1986 and 1987 (cont)

Station: SBC-4 (Big Bear Springs Well)

Date	Flow gpm	Temp °C	pH	TDS	TSS	Tot. Alk.	Tot. Hard.	Ca	Mg	Fe (Tot.)	Na	K	HCO_3	SO_4	Cl	Nit.
3/20/86	UK	3	8.0	268	22	244	251	53	29	0.07	4.0	1.0	----	33	2.0	0.20
4/23/86	UK	2	7.9	320	3,840	276	295	55	38	0.07	9.5	1.5	337	40	5.0	0.36
5/13/86	UK	2	7.5	400	1,590	277	336	74	37	10.0	17	1.4	338	79	6.0	0.51
6/15/86	UK	3	8.0	380	3.0	268	288	70	28	0.08	4.0	1.0	327	19	4.0	0.31
7/23/86	UK	3	8.0	288	----	270	292	72	27	0.05[1]	4.2	0.8	329	21	3.0	0.58
9/24/86	UK	6	8.2	300	----	264	293	58	36	0.06[1]	5.0	1.0	323	25	5.0	0.24
10/01/86		UK	5	8.0	262	----	258	287	53	38	0.05[1]	4.0	1.0	315	27	4.00.18
1/05/87	UK	4	8.1	294	18	256	285	58	34	0.25	4.0	1.0	312	30	4.0	0.24
4/07/87	4[2]	2	8.1	272	19	262	286	35	48	0.15	5.0	1.0	319	33	4.0	0.24
8/26/87	UK	12	8.0	264	11	276	303	72	30	0.18	4.0	1.0	337	26	4.0	0.58
9/24/87	D															
10/05/87		UK	9	8.0	296	----	----	304	67	33	0.1	4.0	1.0	338	30	4.0----

Station: SBC-5 (Birch Spring)

Date	Flow gpm	Temp °C	pH	TDS Alk.	TSS Hard.	Tot.	Tot. (Tot.)	Ca	Mg	Fe	Na	K	HCO_3	SO_4	Cl	Nit.
4/07/87	18[2]	4	7.8	412	2.0	322	412	87	48	0.05	7.0	2.0	392	102	7.0	0.09
7/15/87	D[2]															
8/26/87	D[2]															
9/24/87	D[2]															
10/05/87		D[2]														
11/05/87		D[2]														
12/04/87		D[2]														

Station: SBC-6 (COP Development Spring)

Date	Flow gpm	Temp °C	pH	TDS Alk.	TSS Hard.	Tot.	Tot. (Dis.)	Ca	Mg	Fe	Na	K	HCO_3	SO_4	Cl	Nit.
3/20/86	D															
4/23/86	D															
7/23/86	D															
8/12/86	D															
9/24/86	12	9	8.0 458	----	291	331	83 30	0.5	5.0	1.0	355	1.0 6.0 0.05				
10/01/86	2.4	6	7.3 362	----	271	302	71 30	0.06	4.0	1.0	331	15.0	6.0	0.03		
1/05/87	D															
2/06/87	D															
3/26/87	D															
4/07/87	D															
5/15/87	D															
6/17/87	D															
7/15/87	D															
8/26/87	D															
9/24/87	D															
10/05/87		D														
11/05/87		D														
12/04/87		D														

[1] dissolved Fe D = dry units in mg/l unless noted otherwise
[2] Flows measured at Big Bear and Birch Springs overflows UK = unknown

Table 7-3 Baseline Water Quality Data - Annual Averages

Param.	BC-1 1988	BC-1 1995	BC-2 1988	BC-2 1995	BC-3 1988	BC-3 1995
Flow	37	56	33.5	174	Dry	Dry
Temp.	4.7	10.8	4.3	12.3		
pH.	8.0	8.6	7.9	8.5		
Cond.	480	757	503	643		
DO	N/R	5.4	N/R	5.6		
Settleable	10.7	17	5.1	2.5		
TSS	2,765	3,618	1,926	1,198		
TDS	399	468	418	338		
Hardness	345	372	346	288		
Carbonate	0.0	16.8	0.0	7.8		
Bicarbonate	254	1,019	260	606		
Ca	52	53	53	51		
Cl	6.3	6.8	6.0	6.5		
Fe total	N/R	26.4	23	9.5		
Fe Diss.	N/D	N/D	0.09	N/D		
Mg	53	58	52	38		
Mn total	N/R	0.7	0.46	0.23		
Mn diss.	<0.02	N/D	<0.02	N/D		
K	3.3	4.3	3.4	2.5		
Na	8.8	9.8	8.4	5.8		
Lab Cond.	N/R	710	785	556		
Sulfate	150	148	150	73		
O&G	N/D	N/D	N/D	N/D		
Al	<0.1	N/D	0.1	N/D		
As	N/D	N/D	N/D	N/D		
B	0.11	0.20	0.10	0.15		
Cd	N/D	N/D	N/D	N/D		
Cu	0.03	N/D	N/R	N/D		
Pb	N/D	N/D	N/D	N/D		
Mo	N/D	N/D	N/D	N/D		
Nitrogen	0.03	<0.5	0.04	<0.5		
Nitrate	0.25	0.4	0.27	0.13		
Nitrite	N/D	0.04	N/D	0.04		
Phosphate	N/D	0.30	<0.01	0.19		
Se	N/D	N/D	N/D	N/D		
Zn	N/D	N/D	N/D	N/D		

N/D = Not Detected
N/R = Not Reported
<## = Average value is below the detection limit.

Table 7-3 Baseline Water Quality Data - Annual Averages (Cont)

Param.	SBC-3 1988	SBC-3 1995	SBC-6 1988	SBC-6 1995	SBC-9[1] 1988	SBC-9 1995	SBC-10[1]	SBC-10
Flow	Dry	28.2’	Dry	Dry	114	151	237	23
Temp.		9.4			5.8	10.8	8.8	9.6
pH.		7.3			7.9	7.8	7.5	7.9
Cond.		3,987			484	484	638	664
TDS		2,230			360	330	359	355
Hardness		1,508			325	317	336	325
Carbonate		3.3			0	4	0	7.5
Bicarbonate		462			335	342	338	315
Ca		574			77	74	85	72
Cl		34			4.4	5.3	12.5	7.0
Fe total		2.9			0.17	<0.1	0.13	N/D
Fe Diss.		N/D			N/R	N/D	N/R	N/D
Mg		250			32	32	30	35
Mn total		0.13			N/D	N/D	0.02	N/D
Mn diss.		<0.1			N/R	N/D	N/R	N/D
K		12.3			1.7	1.5	N/D	2.5
Na		55			4.2	4.3	2.5	4.0
Lab Cond.		2,496			610	580	655	581
Sulfate		1,308			56.9	32.8	59.5	48.5
O&G								
Al		N/D			<0.1	N/D	N/D	N/D
As		<0.01			N/D	N/D	<0.002	N/D
B		0.6			0.07	0.13	0.05	0.1
Cd		N/D			N/D	N/D	N/D	N/D
Cu		N/D			0.03	N/D	<0.01	N/D
Pb		N/D			N/D	N/D	N/D	N/D
Mo		N/D			N/D	N/D	N/D	N/D
Nitrogen		N/D			0.11	N/D	0.23	N/D
Nitrate		0.33			0.07	N/D	0.12	<0.1
Nitrite		0.01			N/D	<0.01	<0.01	N/D
Phosphate		0.06			0.18	0.01	<0.01	0.015
Se		N/D			N/D	N/D	N/D	N/D
Zn		0.02			0.19	N/D	<0.01	0.01

N/D = Not Detected
N/R = Not Reported
<## = Average value is below the detection limit.
[1]Trace metals analyzed in total form.

Table 7-3 Baseline Water Quality Data - Annual Averages (Cont)

Param.	SBC-4[1] 1988	SBC-4[2] 1991	SBC-4[2] 1992	SBC-4[2] 1993	SBC-4 1994	SBC-4 1995	SBC-5[2] 1991	SBC-5[2] 1992	SBC-5[2] 1993	SBC-5 1994	SBC-5 1995
Flow	6.3	119	116	118	120	107	31.4	28.4	25.7	22.8	20.9
Temp.	6.7	8.1	10.4	13.4	14.3	12.0	8.0	11.6	14.0	14.1	12.2
pH.	7.9	7.7	7.1	7.4	7.4	7.0	7.5	7.3	7.1	6.9	7.1
Cond.	300	483	568	554	404	418	63	672	719	533	385
TDS	292	381	331	335	312	393	323	470	465	438	482
Hardness	294	347	367	316	292	317	440	431	409	385	392
Carbonate	0.0	1.3	0.0	N/D	N/D	N/D	N/D	N/D	N/D	N/D	N/D
Bicarbonate	319	352	338	327	323	332	382	353	331	371	380
Ca	60	84	93	80	70	73	102	103	92	86	85
Cl	4.7	7.8	13.6	34.8	5.5	6.3	12.1	14.5	12.0	7.0	7.8
Fe total	N/R	0.15	0.03	0.09	N/D	N/D	0.06	0.04	0.12	N/D	N/D
Fe Diss.	N/D	N/R	N/R	N/R	N/D	N/D	N/R	N/R	N/R	N/D	N/D
Mg	35	34	33	28	29	33	45	42	43	42	43
Mn total	N/R	<0.01	<0.01	0.01	N/D	N/D	<0.01	<0.01	0.01	N/D	N/D
Mn diss.	N/D	N/R	N/R	N/R	N/D	N/D	N/R	N/R	N/R	N/D	N/D
K	1.0	4.3	0.3	0.6	N/D	1.5	2.4	1.1	1.2	N/D	2.3
Na	4.0	4.9	3.6	3.5	3.3	5.0	6.5	5.7	4.3	3.3	7.0
Lab Cond.	N/R	550	636	554	562	618	735	730	719	744	766
Sulfate	27	65	48	40	49	62	126	141	114	103	96
O&G	N/D	<5	N/D	N/D	N/D	N/D	N/D	N/D	N/D	N/D	N/D
Al	N/D	<0.5	<0.5	N/D	N/D	N/D	<0.5	<0.5	<0.5	N/D	N/D
As	N/D	N/D	<0.002	0.007	N/D	N/D	N/D	<0.002	N/D	N/D	N/D
B	0.43	0.03	0.07	0.11	<0.1	0.15	0.08	0.14	0.12	0.10	0.51
Cd	N/D	<0.005	<0.005	N/D	N/D	<0.01	N/D	<0.005	N/D	N/D	N/D
Cu	N/R	<0.01	<0.01	2.5	N/D	N/D	<0.01	<0.01	N/D	N/D	N/D
Pb	N/D	N/D	0.002	N/D	N/D	N/D	N/D	0.002	N/D	N/D	N/D
Mo	N/D	<0.2	N/D	<0.2	N/D	N/D	N/D	N/D	<0.2	N/D	N/D
Nitrogen	0.09	0.19	0.07	0.05	N/D	N/D	0.18	0.01	0.02	N/D	N/D
Nitrate	0.26	0.16	0.19	0.24	0.32	0.15	N/D	0.13	37.8	0.18	0.10
Nitrite	N/D	N/D	0.05	0.05	N/D	N/D	<0.01	0.01	<0.01	<0.01	N/D
Phosphate	N/D	0.04	<0.01	0.01	0.07	0.09	0.01	0.03	0.02	0.06	0.10
Se	N/D	N/D	N/D	0.003	N/D	N/D	N/D	N/D	<0.002	N/D	N/D
Zn	<0.01	0.04	0.13	<0.01	0.02	N/D	0.01	0.04	0.01	<0.03	<0.01

N/D = Not Detected
N/R = Not Reported
<## = Average value is below the detection limit.
[1]Sample taken from spring overflow.
[2]Trace metals analyzed in total form.

Groundwater Movement

The movement of groundwater in the permit area is discussed in Appendix 7-N, section 2.4.3 and Appendix 7-J, section 6.0. Groundwater movement is strongly controlled by faults and the dip of strata. A stratigraphic cross-section showing the piezometric surfaces for the three Star Point aquifers is shown in Appendix 7-N, Figure 2-2. Plates 7N-3, 7N-4, and 7N-5 show the piezometric surface contours and top-of-unit contours for each aquifer. Table 7.1-4 summarizes the initial water levels from the four in-mine wells (DH-1A, DH-2, DH-3 and DH-4) and surface well SDH-1, shown on Plate 7-4. All three aquifers exhibit movement to the South, with an Easterly component, which varies for each aquifer. Essentially, the groundwater movement follows the regional and local dip of the beds.

Drill holes MW-114, MW-116 and MW-117 are located East of the Bear Canyon Fault. Plate 7J-2 shows the relationship of the potentriometric surfaces on each side of the fault. Plate 7-4A shows the piezometric surface contours for the uppermost aquifer within the Wild Horse Ridge area. No hydrology information is available for the WHR drill holes.

Exploration holes were also drilled upwards to evaluate potential perched aquifers in the area of the Tank Seam. Table 7-5 summarizes the results of this drilling. With the exception of TS-13, all of the drill holes were essentially dry. TS-13 initially flowed approximately 0.5 gpm and decreased to approximately 0.1 gpm by 1997.

Table 7-4 In-Mine and Surface Drillhole Water Level Measurements

Site	Elev. (ft)	Spring Canyon Water Elev. (ft)	Storrs Water Elev. (ft)	Panther Water Elev. (ft)
DH-1A	7,536'	7,433'	7,320'	7,099'
DH-2	7,557'	7,526'	7,402'	7,237'
DH-3	7,521'	7,396'	7,258'	7,070'
DH-4	7,610'	7,549'	-------	-------
SDH-1	9,387'	7,591'	-------	-------
SDH-2	9,486'	7,964'	-------	-------
SDH-3	9,110'	7,600'	-------	-------
MW-114	9,322'	7,650'	-------	-------
MW-116	9,342'	7,744'	-------	-------
MW-117	9,522	7,746'	-------	-------

Table 7-5 Additional DrillholeWater Level Measurements

Site	Elev. (ft)	Water Level Elev. (ft.)	Discharge (gpm)	Drill Hole Depth (ft)	Comments
lu	7509	None	____	200	Drilled vertical into mine roof
ld	7497	None	____	170	
2u	7492	None	____	200	Drilled vertical into mine roof
6d	7460	None	____	100	
7d	7460	None	____	100	
9d	7474	None	____	100	
10d	7509	None	----	200	
11d	7494	None	____	100	
12d	7516	None	----	100	
13d	7505	None	----	100	
14d	7508	None	----	100	
WM_A	7486	None	____	25	Drilled 45 deg up from horiz into working face
WM_B	7493	None	____	60	
WM_C	7130	None	____	50	
WM_D	7220	None	____	46	
WM_E	7430	None	____	400	
TS-6	7,553'	None	<0.1	297'	Drilled vertical into mine roof
TS-7	7,557'	None	Dry	300'	Drilled vertical into mine roof
TS-8	7,535'	None	Dry	270'	Drilled vertical into mine roof
TS-9	7,495'	None	Dry	260'	Drilled vertical into mine roof
TS-10	7,505'	None	Dry	240'	Drilled vertical into mine roof
TS-12	7,500'	None	Dry	250'	Drilled vertical into mine roof
TS-13	7,615'	None	0.5	270'	Drilled vertical into mine roof
TS-14	7,525'	None	Dry	250'	Drilled vertical into mine roof

Note: See Plate 6-11 for locations of drillholes TS-6 through TS-14. See Appendix 6-A for drillhole logs of TS-6 through TS-10 and TS-14. No logs are available for holes TS-12 and TS-13. Locations of additional in-mine drillholes are not known, but drillhole logs can be found in Appendix 7-A.

Three general groundwater flow conditions are hypothesized to exist at the site;

1. Flows exist which follow vertical joints near the surface and move laterally when impermeable beds of shale or mudstone are encountered. These flows are generally expressed as surface seeps, which occur close to the original recharge source, and only occur immediately after periods of recharge.

2. Flows exist which move downward through permeable strata and/or faults and joints in the interior of the mountain until impermeable beds of shale or mudstone are encountered. These flows then move laterally, generally following the dip of the strata, or following faults or fractures, which laterally conduct the water. Lateral movement continues until other vertically permeable lithology or zones of fracturing are encountered, in which vertical movement may continue, or until the land surface is reached, in which the flow discharges as springs or seeps. These flows generally occur year-round. When aquifers of this nature are encountered by mining, flows may be high initially, and then eventually drop to some continuous base flow.

3. Flows occur which are derived from local perched aquifers (sandstone lenses or localized fractures) and are encountered in-mine. These flows are expressed as roof drips and seeps, and will generally flow for a short period of time until the sandstone lenses or fractures are dewatered, and then cease flowing, indicating no apparent recharge.

Permeability of the first condition is secondary and may be up to several hundred ft/yr. Permeability of the second condition is mostly primary and low, on the order of 10 to 20 ft/yr. For the three Star Point sandstone aquifers, slug tests were performed in the in-mine drillholes to determine the permeability of the sandstones. The results of these tests are shown in Appendix 7-N, Table 4-1.

Groundwater Development

No development of groundwater through existing or future wells is planned within the permit expansion area. Use of groundwater in the area consists of the Big Bear Springs flow, which is entirely diverted for culinary use by the Huntington City community, and in-mine flows, which are collected in sumps and used for mining, dust control, and culinary water for Bear Canyon.

Wells and Users

Wells in and adjacent to the permit area (Appendix 7-A and Appendix 7-N) are monitoring wells installed by C. W. Mining.

Mine Dewatering

Dewatering of the mine was not required prior to 1991 due to the low water volumes encountered. Seepage into the mine has been controlled by pumping excess water to sump locations within the mine where it is allowed to settle, and then it is pumped out of the mine and discharged into Bear Creek, as governed by the mine discharge permit (Appendix 7-B).

A discharge line was installed in 1991 to the approved discharge point located above the scale house (Plate 7-1C). A totalizing flow meter is installed to monitor flows. Flows are logged and reported to the Utah Division of Water Quality with the monthly Discharge Monitoring Reports (DMR). Copies of these reports will be included in the quarterly Water Monitoring Reports.

On March 30, 1989, the State of Utah, Department of Health, stated that "a permit is not required" for overflow from the Bear Canyon culinary system (Appendix 7-B). The culinary overflow is piped into culvert C-8U (Plate 7-1C).

Expected mine water is further discussed in the Probable Hydrologic Consequence Determination (PHC), Appendix 7-J. Currently, no water is discharged from the Tank Seam due to the lack of mine water inflow. Similar conditions are expected in both Seams within Wild Horse Ridge.

Ground Water Site Selection

C. W. Mining has selected sites that have been developed for beneficial use, are the primary source of surface water systems, or contain large flows, for monitoring. The parameters tested for and the schedule followed are the ones determined to be adequate based on the study found in Appendix 7J. Three years of baseline data will be collected which exceeds the minimum required by law. The Division recommended list for baseline parameters will be followed which exceeds the minimum required by law. Additionally every five years baseline parameters will be collected. The rest of the time filed readings will be collected which includes flow data and enough parameters to determine an impact. These sites are listed in Table 7-14.

724.200 Surface Water Information

Scope

The purpose of this section is to provide background information on the surface hydrology characteristics of the Co-Op Bear Canyon Mine permit area and the surrounding regional area~~.~~; also, to present a plan of action for complying with the requirements of the Office of Surface Mining (OSM) and the Utah Division of Oil, Gas and Mining (DOGM). In particular, this section includes an evaluation of the geological and hydrological setting of the mine, its relation to the regional ground water and surface water hydrology and its probable impact on the groundwater and surface water systems. Appendix 7-J (PHC), Section 7.0 also contains information pertaining to the surface water hydrology.

Information from field reconnaissance and a review of data from various sources was used in compiling this surface water hydrology section. The data sources included information from Co-Op, reports by the U.S. Geological Survey, Utah Geological and Mineral Survey, U.S. Forest Service and mine application permits on file with OSM (specifically those in the Huntington Canyon area). References used are listed at the end

Surface Water in Regional and Adjacent Areas

The San Rafael River Basin of the Upper Colorado River Region is generally classified as an arid basin. The upper drainages along the Wasatch Plateau receive enough snow precipitation to be classified as semi-arid to sub-humid due to the amount of precipitation increase with altitude.

There are eight major reservoirs in the basin. Seven are mainly for irrigation with a total capacity of 85,000 acre-ft and one, with a capacity of 30,530 acre-ft, is used as the water supply for a power plant. Diversions during irrigation season, April to November, from Huntington, Cottonwood, and Ferron Creeks nearly deplete flows downstream from these diversions. Flows downstream during this period are mainly irrigation return flows along with some groundwater seepage.

At points of major diversions on the Huntington, Cottonwood, and Ferron Creeks the water quality is excellent for irrigation, with dissolved-solids concentrations of less than 500 mg/l. But water at the mouths of these creeks has markedly larger dissolved-solids concentrations. This is mainly due to two factors:

a. In the area between major diversions and the mouths of the creeks, the creeks cross a belt of exposed Mancos Shale 10 to 15 miles wide.

b. This area is also where practically all the intensive irrigation in the San Rafael River Basin is practiced. (Mundoff, '82).

The upper drainage of Huntington Creek encompasses about 200 sq mi of mountainous country in the Wasatch Plateau. About 90 pct of the area is higher than 8,000 ft. The average channel gradient along the stream in the area is about 100 ft/mile. In the lower reaches the stream is in deep, narrow canyons, and surface relief between the stream channel and the top of adjacent canyon walls is typically 2,000 ft or more. (Danielson, '81).

Quantity and Quality of Surface Water

According to Danielson, "...about 65 pct of the annual discharge at the Huntington Creek station (0931800) occurs during the snowmelt period (April-July). Because most of the stream flow is derived from snowmelt, annual discharge to the gaging station correlates well with the April 1 snow pack water content." Approx 80 pct of the discharge from these streams is during the snowmelt from April to July.

As part of the Danielson study, chemical analyses were performed on selected surface water samples from the area. It should be noted that none of the analyzed chemical constituents were found in concentrations that exceeded the drinking water standards of the U.S. Environmental Protection Agency (1976). Danielson also noted that, "The predominant dissolved chemical constituents in water in Huntington Creek upstream from gauging station 0931800 were calcium and bicarbonate. The predominant dissolved chemical constituents in water in tributaries to Huntington Creek were usually calcium, magnesium, and bicarbonate. However, during periods of base flow the concentrations of sulfate in water at the mouths (of the tributaries) were significantly higher than sulfate concentrations in water in Huntington Creek. Water from the Star Point commonly contains slightly higher concentrations of both dissolved solids and sulfate than water from younger rocks in the area."

Water Uses

Most of the surface water from the drainage is diverted for use as crop irrigation. The only other major use is supply water to the Huntington Power plant. The reservoirs in the area have been built to supplement this use. Some water in the area, particularly springs, is issued for livestock watering or as culinary water.

Water rights have been obtained by Co-Op in sufficient quantities for all of the mine's needs. Table 7-6 contains a listing of water rights in the area and Plate ~~7-4~~ 7-12 indicates their various locations. Information on the water rights can be accessed on the Utah Division of Water Rights website at http://nrwrt1.nr.state.ut.us/wrinfo/query.asp. Additional information about the water rights owned by the Co-Op man can be found in Appendix 7-C. Appendix 7-D contains a copy of an agreement between Co-Op and Huntington City with regards to protection of Huntington City's Big Bear Creek Spring (Huntington Spring) water source.

Table 7-6 Area Water Rights

Water Right	Owner	Priority Date	Place of Use	Point of Diversion	Nature Of Use
91-251	ANR	0/0/1900	(1) S 215 ft W 120 ft from NE cor, Sec 12, T 20S, R 6E, SLBM	Surface	Irrigation/ Domestic
91-316	ANR	0/0/1875	spring located in SW4NE4 Sec 10, T18S, R5E, SLBM	Spring	Stockwater
93-116	U.S.F.S	0/0/1875	From a point in NE4SE4 Sec 08, T15S, R7E, SLBM, to a point in SE4SE4 Sec 09, T16S, R7E, SLBM.	Point 2 Point	Stockwater
93-129	Nevada Electric	0/0/1875	From a point in NW4NW4 Sec 15, T16S, R7E, SLBM, to a point in NW4NW4 Sec 15, T16S, R7E, SLBM.	Point 2 Point	Stockwater
93-130	U.S.F.S	0/0/1875	from a point in SW4NW4 Sec 15, T16S, R7E, SLBM, to a point in SE4NW4 Sec 22, T16S, R7E, SLBM.	Point 2 Point	Stockwater
93-131	C.O.P Coal	0/0/1875	from a point in NW4SE4 Sec 22, T16S, R7E, SLBM, to a point in SW4SE4 Sec 22, T16S, R7E, SLBM	Point 2 Point	Stockwater
93-138	C.O.P Coal	0/0/1875	from a point in NE4NE4 Sec 15, T16S, R7E, SLBM, to a point in NE4SE4 Sec 22, T16S, R7E, SLBM	Point 2 Point	Stockwater
93-139	U.S.F.S	0/0/1875	from a point in NW4NW4 Sec 11, T16S, R7E, SLBM, to a point in SE4SE4 Sec 10, T16S, R7E, SLBM	Point 2 Point	Stockwater
93-140	Utah Trust Land	0/0/1875	from a point in NE4SW4 Sec 02, T16S, R7E, SLBM, to a point in SW4SW4 Sec 02, T16S, R7E, SLBM.	Point 2 Point	Stockwater
93-141	C.O.P Coal	0/0/1875	from a point in NW4NW4 Sec 14, T16S, R7E, SLBM, to a point in SE4NE4 Sec 15, T16S, R7E, SLBM	Point 2 Point	Stockwater
93-142	Utah Trust Land	0/0/1875	from a point in NW4NW4 Sec 01, T16S, R7E, SLBM, to a point in NE4NW4 Sec 14, T16S, R7E, SLBM	Point 2 Point	Stockwater
93-143	Nevada Electric	0/0/1875	Spring located in NW4SW4 Sec 26, T16S, R7E, SLBM	Spring	Stockwater
93-144	U.S.F.S	0/0/1875	from a point in SE4SE4 Sec 22, T16S, R7E, SLBM, to a point in SE4SE4 Sec 22, T16S, R7E, SLBM	Point 2 Point	Stockwater
93-146	Nevada Electric	0/0/1875	from a point in SE4NE4 Sec 27, T16S, R7E, SLBM, to a point in SE4NE4 Sec 27, T16S, R7E, SLBM	Point 2 Point	Stockwater
93-147	BLM	0/0/1860	from a point in NW4NW4 Sec 35, T16S, R7E, SLBM, to a point in NE4NW4 Sec 35, T16S, R7E, SLBM	Point 2 Point	Stockwater
93-148	BLM	0/0/1902	from a point in SE4SW4 Sec 26, T16S, R7E, SLBM, to a point in SE4SW4 Sec 26, T16S, R7E, SLBM	Point 2 Point	Stockwater
93-149	Nevada Electric	0/0/1875	from a point in SW4SW4 Sec 26, T16S, R7E, SLBM, to a point in SW4SW4 Sec 26, T16S, R7E, SLBM.	Point 2 Point	Stockwater
93-150	Nevada Electric	0/0/1875	from a point in NE4NW4 Sec 24, T16S, R7E, SLBM, to a point in NE4SE4 Sec 26, T16S, R7E, SLBM.	Point 2 Point	Stockwater
93-151	U.S.F.S	0/0/1875	from a point in NE4NW4 Sec 13, T16S, R7E, SLBM, to a point in SW4SW4 Sec 13, T16S, R7E, SLBM.	Point 2 Point	Stockwater
93-155	Utah Trust Lands	0/0/1902	from a point in NE4NW4 Sec 29, T16S, R8E, SLBM, to a point in SW4SW4 Sec 29, T16S, R8E, SLBM.	Point 2 Point	Stockwater
93-156	A.U. Mines INC.	0/0/1902	from a point in NW4NE4 Sec 29, T16S, R8E, SLBM, to a point in NW4NE4 Sec 29, T16S, R8E, SLBM	Point 2 Point	Stockwater
93-157	A.U. Mines INC.	0/0/1902	from a point in NW4SE4 Sec 20, T16S, R8E, SLBM, to a point in SW4SE4 Sec 20, T16S, R8E, SLBM	Point 2 Point	Stockwater
93-158	C.O.P Coal	0/0/1902	from a point in NE4NW4 Sec 20, T16S, R8E, SLBM, to a point in SE4NW4 Sec 20, T16S, R8E, SLBM.	Point 2 Point	Stockwater
93-160	C.O.P Coal	0/0/1902	from a point in SW4NW4 Sec 07, T16S, R8E, SLBM, to a point in SE4SW4 Sec 17, T16S, R8E, SLBM	Point 2 Point	Stockwater
93-161	C.O.P Coal	0/0/1902	spring located in NW4SE4 Sec 07, T16S, R8E, SLBM	Spring	Stockwater
93-163	C.O.P Coal	0/0/1902	from a point in Lot 4 Sec 06, T16S, R8E, SLBM, to a point in NE4NE4 Sec 15, T16S, R8E, SLBM.	Point 2 Point	Stockwater
93-165	Trust Lands	0/0/1902	from a point in SW4SW4 Sec 29, T16S, R8E, SLBM, to a point in SW4SW4 Sec 29, T16S, R8E, SLBM	Point 2 Point	Stockwater
93-166	U.S.F.S	0/0/1875	from a point in NE4NE4 Sec 19, T16S, R8E, SLBM, to a point in SE4NE4 Sec 30, T16S, R8E, SLBM	Point 2 Point	Stockwater
93-167	C.O.P Coal	0/0/1902	from a point in SW4NW4 Sec 18, T16S, R8E, SLBM, to a point in SW4SE4 Sec 18, T16S, R8E, SLBM	Point 2 Point	Stockwater
93-188	U.S.F.S	0/0/1875	from a point in SE4NW4 Sec 05, T16S, R7E, SLBM, to a point in SE4NW4 Sec 04, T16S, R7E, SLBM	Point 2 Point	Stockwater
93-190	U.S.F.S	0/0/1875	from a point at 0 ft., to a point in NE4SE4 Sec 06, T16S, R7E, SLBM.	Point 2 Point	Stockwater
93-192	U.S.F.S	0/0/1875	from a point in NW4SE4 Sec 09, T16S, R7E, SLBM, to a point in NE4SE4 Sec 09, T16S, R7E, SLBM	Point 2 Point	Stockwater
93-193	U.S.F.S	0/0/1875	from a point in SW4SE4 Sec 08, T16S, R7E, SLBM, to a point in NW4SE4 Sec 09, T16S, R7E, SLBM.	Point 2 Point	Stockwater
93-195	U.S.F.S	0/0/1875	from a point in NE4NE4 Sec 20, T16S, R7E, SLBM, to a point in NE4NW4 Sec 22, T16S, R7E, SLBM.	Point 2 Point	Stockwater
93-196	Hiatt, Marena Madden, et Al	0/0/1902	from a point in SW4SE4 Sec 17, T16S, R7E, SLBM, to a point in SW4SE4 Sec 17, T16S, R7E, SLBM	Point 2 Point	Stockwater
93-199	UP&L	0/0/1902	from a point in NW4NW4 Sec 27, T16S, R7E, SLBM,to a point in SE4SW4 Sec 22, T16S, R7E, SLBM	Point 2 Point	Stockwater
93-202	BLM	0/0/1902	from a point in SE4NE4 Sec 35, T16S, R7E, SLBM, to a point in SE4NE4 Sec 35, T16S, R7E, SLBM.	Point 2 Point	Stockwater

93-203	Zions Bank& Frank A	0/0/1902	from a point in NW4NW4 Sec 02, T17S, R7E, SLBM, to a point in NE4SE4 Sec 35, T16S, R7E, SLBM.	Point 2 Point	Stockwater
93-210	Zionsl Bank & Frank A	0/0/1902	from a point in NW4SW4 Sec 35, T16S, R7E, SLBM, to a point in SE4SW4 Sec 35, T16S, R7E, SLBM	Point 2 Point	Stockwater
93-214	Utah Power And Light	0/0/1902	from a point in SW4NW4 Sec 36, T16S, R7E, SLBM, to a point in SE4SE4 Sec 06, T17S, R8E, SLBM.	Point 2 Point	Stockwater
93-217	Utah Power And Light	0/0/1902	from a point in NW4SW4 Sec 01, T17S, R7E, SLBM, to a point in SW4SE4 Sec 36, T16S, R7E, SLBM.	Point 2 Point	Stockwater
93-219	HCIC	0/0/1875	(1) N 40 ft W 1520 ft from SE cor, Sec 34, T 15S, R 7E, SLBM, (2) N 1550 ft W 50 ft from SE cor, Sec 34, T 15S, R 7E, SLBM	Surface	Irrigation/Power/Industrial/Domestic/Minicipal/Stock Water
93-220	HCIC	0/0/1875	(1) S 1535 ft E 785 ft from NW cor, Sec 36, T 16S, R 7E, SLBM	Surface	Irrigation/Power/Industrial/Domestic/Minicipal/Stock Water
93-253	HCIC	0/0/1875	(1) N 2045 ft E 185 ft from S4 cor, Sec 26, T 16S, R 7E, SLBM	Surface	Stock Water/ Irrigation/ Domestic/ Municipal
93-254	HCIC	0/0/1875	(1) N 1750 ft W 95 ft from S4 cor, Sec 09, T 16S, R 7E, SLBM	Surface	Stock Water/ Irrigation/ Domestic/ Municipal
93-259	HCIC	0/0/1875	spring located in NW4SW4 Sec 17, T16S, R7E, SLBM	Spring	Stockwater
93-260	HCIC	0/0/1902	spring located in SW4SE4 Sec 17, T16S, R7E, SLBM	Spring	Stockwater
93-303	HCIC	0/0/1875	(1) S 2040 ft W 530 ft from NE cor, Sec 27, T 16S, R 7E, SLBM	Surface	Stock Water/ Irrigation/ Domestic/ Minicpal
93-304	HCIC	0/0/1875	(1) N 1060 ft E 685 ft from W4 cor, Sec 26, T 16S, R 7E, SLBM	Surface	Irrigation/ Domestic
93-309	HCIC	0/0/1875	(1) S 1770 ft W 980 ft from NE cor, Sec 27, T 16S, R 7E, SLBM	Surface	Irrigation/ Domestic/ Municipal/Stock Water
93-310	HCIC	0/0/1875	(1) N 2030 ft E 60 ft from SW cor, Sec 26, T 16S, R 7E, SLBM	Surface	Irrigation/Domestic/Municipal/ Stock Water
93-317	U.S.F.S	0/0/1875	spring located in SE4NW4 Sec 10, T18S, R5E, SLBM	Spring	Stockwater
93-390	Nevada Electric	0/0/1875	from a point in SW4SE4 Sec 22, T16S, R7E, SLBM, to a point in SW4SE4 Sec 22, T16S, R7E, SLBM	Point 2 Point	Stockwater
93-508	ANR	0/0/1902	spring located in Lot 2 Sec 06, T16S, R8E, SLBM	Spring	Stockwater
93-509	C.O.P Coal	0/0/1875	spring located in SE4NW4 Sec 06, T16S, R8E, SLBM	Spring	Stockwater
93-510	C.O.P Coal	0/0/1902	spring from a point at 0 ft., to a point in NE4NE4 Sec 15, T16S, R8E, SLBM	Spring	Stockwater
93-511	IPA	0/0/1902	spring located in Lot 7 Sec 06, T16S, R8E, SLBM	Spring	Stockwater
93-512	ANR	0/0/1902	from a point in SE4NE4 Sec 05, T16S, R8E, SLBM, to a point in SE4NE4 Sec 09, T16S, R8E, SLBM	Point 2 Point	Stockwater
93-513	Utah Trust Lands	0/0/1902	from a point in SW4NW4 Sec 10, T16S, R8E, SLBM, to a point in NW4SW4 Sec 10, T16S, R8E, SLBM.	Point 2 Point	Stockwater
93-514	C.O.P Coal	0/0/1902	from a point in SW4SW4 Sec 10, T16S, R8E, SLBM, to a point in SW4SW4 Sec 10, T16S, R8E, SLBM	Point 2 Point	Stockwater
93-522	IPA	0/0/1902	(1) N 950 ft W 1430 ft from SE cor, Sec 06, T 16S, R 8E, SLBM	Surface	Mining/ Stock Water
93-565	Utah Trust Land	0/0/1902	from a point in NE4NW4 Sec 28, T16S, R8E, SLBM, to a point in NE4SE4 Sec 10, T17S, R8E, SLBM.	Point 2 Point	Stockwater
93-928	HCIC	0/0/1902	(1) N 1240 ft E 270 ft from SW cor, Sec 21, T 14S, R 6E, SLBM	Surface	Irrigation/ Power/ Industrial/ Fish Culture/ Stock Water/ Domestic
93-955	Utah Water Recources	8/8/1922	(1) N 1240 ft E 270 ft from SW cor, Sec 21, T 14S, R 6E, SLBM	Surface	Irrigation/ Stock Water
93-964	U.S. Fuel	8/17/1929	(1) S 1450 ft E 1400 ft from NW cor, Sec 05, T 16S, R 8E, SLBM	Surface	Industrial
93-970	ANR	4/10/1930	(1) N 1831 ft W 1012 ft from SE cor, Sec 08, T 16S, R 8E, SLBM	Surface	Industrial
93-1063	Utah Water Recources	3/30/1961	(1) N 1641 ft E 938 ft from SW cor, Sec 21, T 14S, R 6E, SLBM, (2) S 2220 ft W 2200 ft from NE cor, Sec 33, T 14S, R 6E, SLBM,(3) S 3272 ft W 282 ft from NE cor, Sec 33, T 14S, R 6E, SLBM, (4) N 165 ft W 750 ft from S4 cor, Sec 05, T 17S, R 8E, SLBM	Surface	Irrigation/ StockWater/ Domestic
93-1067	C.O.P Coal	1/20/1964	(1) N 79 ft E 75 ft from SW cor, Sec 24, T 16S, R 7E, SLBM	Surface	Irrigation/ Domestic/ Mining
93-1089	ANR	7/0/1910	(1) N 1500 ft W 85 ft from SE cor, Sec 08, T 16S, R 8E, SLBM	Under ground	Irrigation
93-1115	Utah Power And Light	12/10/1968	(1) S 1535 ft E 785 ft from NW cor, Sec 36, T 16S, R 7E, SLBM , (2) N 2350 ft W 500 ft from SE cor, Sec 10, T 17S, R 7E, SLBM	Surface	Irrigation/ Power/ Industrial
93-1129	Utah Trust Lands	0/0/1875	spring located at N3000 ft. E350 ft. from SW corner, Sec 10, T16S, R8E, SLBM	Spring	Stockwater
93-1139	HCIC	0/0/1890	(1) S 940 ft W 550 ft from N4 cor, Sec 28, T 14S, R 6E, SLBM	Surface	Irrigation/Power/Fish Culture/Industrial/Industrial /StockWater/Municipal/ Domestic
93-1182	Peabody Coal Co.	0/0/1902	from a point in NW4SE4 Sec 26, T16S, R7E, SLBM, to a point in SW4SE4 Sec 26, T16S, R7E, SLBM.	Point 2 Point	Stockwater
93-1183	Pacificorp UP&L	0/0/1902	from a point in NE4SW4 Sec 22, T16S, R7E, SLBM, to a point in NE4SW4 Sec 22, T16S, R7E, SLBM	Point 2 Point	Stockwater
93-1187	U.S.F.S	0/0/1875	from a point in NE4SW4 Sec 20, T16S, R8E, SLBM, to a point in NE4SW4 Sec 20, T16S, R8E, SLBM.	Point 2 Point	Stockwater

93-1408	U.S.F.S	0/0/1875	spring located in NW4NE4 Sec 06, T16S, R7E, SLBM	Spring	Stockwater
93-1411	U.S.F.S	0/0/1875	spring located in NE4SW4 Sec 09, T16S, R7E, SLBM	Spring	Stockwater
93-1425	U.S.F.S	0/0/1875	spring located in SE4SW4 Sec 21, T16S, R8E, SLBM	Spring	Stockwater
93-1426	U.S.F.S	0/0/1875	spring located in SW4NW4 Sec 21, T16S, R8E, SLBM	Spring	Stockwater
93-1427	U.S.F.S	0/0/1875	spring located in NE4NE4 Sec 20, T16S, R8E, SLBM	Spring	Stockwater
93-1428	U.S.F.S	0/0/1875	spring located in NE4NE4 Sec 19, T16S, R8E, SLBM	Spring	Stockwater
93-1429	U.S.F.S	0/0/1875	spring located in NE4SE4 Sec 13, T16S, R7E, SLBM	Spring	Stockwater
93-1430	U.S.F.S	0/0/1875	spring located in SE4SE4 Sec 12, T16S, R7E, SLBM	Spring	Stockwater
93-1431	U.S.F.S	0/0/1875	spring located in NE4SE4 Sec 12, T16S, R7E, SLBM	Spring	Stockwater
93-1432	U.S.F.S	0/0/1875	spring located in SE4NE4 Sec 12, T16S, R7E, SLBM	Spring	Stockwater
93-1433	U.S.F.S	0/0/1875	spring located in NW4SE4 Sec 12, T16S, R7E, SLBM	Spring	Stockwater
93-1434	U.S.F.S	0/0/1875	spring located in NW4SW4 Sec 11, T16S, R7E, SLBM	Spring	Stockwater
93-1435	U.S.F.S	0/0/1875	spring located in NE4SE4 Sec 10, T16S, R7E, SLBM	Spring	Stockwater
93-1436	U.S.F.S	0/0/1875	spring located in NW4NW4 Sec 11, T16S, R7E, SLBM	Spring	Stockwater
93-1437	U.S.F.S	0/0/1875	spring located in NE4NW4 Sec 01, T16S, R7E, SLBM	Spring	Stockwater
93-1438	U.S.F.S	0/0/1875	spring located in NE4NW4 Sec 01, T16S, R7E, SLBM	Spring	Stockwater
93-2193	HCIC	0/0/1879	(1) N 1750 ft W 95 ft from S4 cor, Sec 09, T 16S, R 7E, SLBM	Surface	Irrigation/ Domestic/ Municipal/ StockWater
93-2194	HCIC	0/0/1884	(1) N 1750 ft W 95 ft from S4 cor, Sec 09, T 16S, R 7E, SLBM	Surface	Irrigation/ Municipal/ StockWater
93-2195	HCIC	0/0/1888	(1) N 1750 ft W 95 ft from S4 cor, Sec 09, T 16S, R 7E, SLBM	Surface	Irrigation/ StockWater
93-2196	HCIC	0/0/1879	(1) N 1060 ft E 685 ft from W4 cor, Sec 26, T 16S, R 7E, SLBM	Surface	Irrigation/ Municipal/ StockWater/ Domestic
93-2197	HCIC	0/0/1884	(1) N 1060 ft E 685 ft from W4 cor, Sec 26, T 16S, R 7E, SLBM	Surface	Irrigation/ Municipal/ StockWater/ Domestic
93-2198	HCIC	0/0/1888	(1) N 1060 ft E 685 ft from W4 cor, Sec 26, T 16S, R 7E, SLBM	Surface	Irrigation/ Municipal/ StockWater/ Domestic
93-2199	HCIC	0/0/1879	(1) N 2045 ft E 185 ft from S4 cor, Sec 26, T 16S, R 7E, SLBM	Surface	Irrigation/ Municipal/ StockWater/ Domestic
93-2200	HCIC	0/0/1884	(1) N 2045 ft E 185 ft from S4 cor, Sec 26, T 16S, R 7E, SLBM	Surface	Irrigation/ Municipal/ StockWater/ Domestic
93-2201	HCIC	0/0/1888	(1) N 2045 ft E 185 ft from S4 cor, Sec 26, T 16S, R 7E, SLBM	Surface	Irrigation/ Municipal/ StockWater/ Domestic
93-2202	HCIC	0/0/1879	(1) S 2040 ft W 530 ft from NE cor, Sec 27, T 16S, R 7E, SLBM	Surface	Irrigation/ Municipal/ StockWater/ Domestic
93-2203	HCIC	0/0/1884	(1) S 2040 ft W 530 ft from NE cor, Sec 27, T 16S, R 7E, SLBM	Surface	Irrigation/ Municipal/ StockWater/ Domestic
93-2204	HCIC	0/0/1888	(1) S 2040 ft W 530 ft from NE cor, Sec 27, T 16S, R 7E, SLBM	Surface	Irrigation/ Stockwater
93-2205	HCIC	0/0/1879	(1) S 1770 ft W 980 ft from NE cor, Sec 27, T 16S, R 7E, SLBM	Surface	Irrigation/ Municipal/ StockWater/ Domestic
93-2206	HCIC	0/0/1884	(1) S 1770 ft W 980 ft from NE cor, Sec 27, T 16S, R 7E, SLBM	Surface	Irrigation/ Stockwater
93-2207	HCIC	0/0/1888	(1) S 1770 ft W 980 ft from NE cor, Sec 27, T 16S, R 7E, SLBM	Surface	Irrigation/ Municipal/ StockWater/ Domestic
93-2208	HCIC	0/0/1879	(1) N 2030 ft E 60 ft from SW cor, Sec 26, T 16S, R 7E, SLBM	Surface	Irrigation/ Municipal/ StockWater/ Domestic
93-2209	HCIC	0/0/1884	(1) N 2030 ft E 60 ft from SW cor, Sec 26, T 16S, R 7E, SLBM	Surface	Irrigation/ Municipal/ StockWater/ Domestic
93-2210	HCIC	0/0/1888	(1) N 2030 ft E 60 ft from SW cor, Sec 26, T 16S, R 7E, SLBM	Surface	Irrigation/ Municipal/ StockWater/ Domestic
93-2220	HCIC	0/0/1879	(1) N 40 ft W 1520 ft from SE cor, Sec 34, T 15S, R 7E, SLBM (2) N 1550 ft W 50 ft from SE cor, Sec 34, T 15S, R 7E, SLBM	Surface	Irrigation/ Municipal/ StockWater/ Domestic
93-2221	HCIC	0/0/1884	(1) N 40 ft W 1520 ft from SE cor, Sec 34, T 15S, R 7E, SLBM (2) N 1550 ft W 50 ft from SE cor, Sec 34, T 15S, R 7E, SLBM	Surface	Irrigation/ Municipal/ StockWater/ Domestic
93-2222	HCIC	0/0/1888	(1) N 40 ft W 1520 ft from SE cor, Sec 34, T 15S, R 7E, SLBM (2) N 1550 ft W 50 ft from SE cor, Sec 34, T 15S, R 7E, SLBM	Surface	Irrigation/ Municipal/ StockWater/ Domestic
93-2223	HCIC	0/0/1879	(1) S 1535 ft E 785 ft from NW cor, Sec 36, T 16S, R 7E, SLBM	Surface	Irrigation/ Municipal/ StockWater/ Domestic/ Power/ Industrial
93-2224	HCIC	0/0/1884	(1) S 1535 ft E 785 ft from NW cor, Sec 36, T 16S, R 7E, SLBM	Surface	Irrigation/ Municipal/ StockWater/ Domestic/ Power/ Industrial
93-2225	HCIC	0/0/1888	(1) S 1535 ft E 785 ft from NW cor, Sec 36, T 16S, R 7E, SLBM	Surface	Irrigation/ Municipal/ StockWater/ Domestic/ Power/ Industrial

93-3033	HCIC	0/0/1875	from a point in NW4SW4 Sec 26, T16S, R7E, SLBM, to a point in NW4SW4 Sec 26, T16S, R7E, SLBM.	Point 2 Point	Stockwater
93-3033	North West Carbon Corp	0/0/1875	from a point in NW4SW4 Sec 26, T16S, R7E, SLBM, to a point in NW4SW4 Sec 26, T16S, R7E, SLBM.	Point 2 Point	Stockwater
93-3047	Utah Trust Lands	0/0/1860	spring located in SW4NE4 Sec 28, T16S, R8E, SLBM.	Spring	Stockwater
93-3171	North West Carbon Corp	0/0/1875	from a point in NW4SW4 Sec 26, T16S, R7E, SLBM, to a point in SW4SW4 Sec 26, T16S, R7E, SLBM	Point 2 Point	Stockwater
93-3195	HCIC	2/28/1980	(1) S 940 ft W 550 ft from N4 cor, Sec 28, T 14S, R 6E, SLBM	Surface	Irrigation/ Industrial/ Power/ Fish Culture/ Stock Water/ Domestic/ Municipal
93-3207	BLM	0/0/1860	from a point in NE4NE4 Sec 27, T16S, R7E, SLBM, to a point in NE4NE4 Sec 27, T16S, R7E, SLBM	Point 2 Point	Stockwater
93-3208	BLM	0/0/1860	from a point in SW4NW4 Sec 26, T16S, R7E, SLBM,to a point in SW4NW4 Sec 26, T16S, R7E, SLBM	Point 2 Point	Stockwater
93-3209	BLM	0/0/1860	from a point in NE4SW4 Sec 26, T16S, R7E, SLBM, to a point in NE4SW4 Sec 26, T16S, R7E, SLBM	Point 2 Point	Stockwater
93-3524	ANR	4/10/1930	(1) N 1831 ft W 1012 ft from SW cor, Sec 09, T 16S, R 8E, SLBM	Surface	Industrial/ Municipal
93-3657	J. O Kingston	0/0/1875	(1) S 1725 ft W 1280 ft from NE cor, Sec 22, T 16S, R 7E, SLBM, (2) N 79 ft E 75 ft from SW cor, Sec 24, T 16S, R 7E, SLBM	Surface	Irrigation/ Stockwater
93-3725	HCIC	0/0/1875	(1) N 1060 ft E 685 ft from W4 cor, Sec 26, T 16S, R 7E, SLBM, (2) N 2030 ft E 60 ft from SW cor, Sec 26, T 16S, R 7E, SLBM, (3) S 1770 ft W 980 ft from NE cor, Sec 27, T 16S, R 7E, SLBM, (4) S 2040 ft W 530 ft from NE cor, Sec 27, T 16S, R 7E, SLBM	Surface	Irrigation/ Municipal/ StockWater/ Domestic/ Power/ Industrial
93-3739	ANR	7/00/1910	(1) N 1500 ft W 85 ft from SE cor, Sec 08, T 16S, R 8E, SLBM	Under ground	Irrigation
93-3745	IPA	4/10/1930	(1) N 1831 ft W 1012 ft from SE cor, Sec 08, T 16S, R 8E, SLBM	Surface	Industrial/ Municipal
93-3746	IPA	4/10/1930	(1) N 1831 ft W 1012 ft from SW cor, Sec 09, T 16S, R 8E, SLBM	Surface	Industrial/ Municipal

Note: This table includes water rights on file with the Utah Division of Water Rights in or near the permit area.

Mine Plan Area Surface Water

The channel of Bear Creek is straddled by the mine plan area. Bear Creek is a perennial stream with flows often frozen during the winter. An ephemeral tributary flows into Bear Creek from the east in the mine plan area. Some of the higher portions of this drainage contain intermittent flows, but this flow is adsorbed by the ground before it reaches Bear Creek.

Measurements at the mouth of Bear Creek made during the Danielson study indicate a significant impact to stream flow from snowmelt, between 18 and 153 gpm (Table 7-7). The headwater springs of Bear Creek issue from the North Horn Formation, a locally recharged water zone. These springs flow over steep, often unstable slopes to the creek bed, which results in high concentrations of suspended solids measurements taken during the Danielson study, which illustrates the high concentrations in Bear Creek.

Concerning the unusually high sediment loads in Bear Creek, Danielson stated the following:

> "Bear Creek transported large quantities of suspended sediment during 1978 and 1979. Springs emerging from the North Horn Formation in the headwaters of Bear Creek continuously erode the shale and mudstone and permit sloughing of large amounts of fine-grained material from the escarpments."

Table 7-7 Stream Flow Measurements (1977-79)

	Date	Discharge (cfs)	(gpm)
Bear Creek (site no. 81)	08-10-78	0.09	40.4
	10-25-78	0.08	35.9
	11-08-78	0.06	26.9
	12-13-78	0.04	18.0
	06-27-79	0.34	152.3
	07-16-79	0.21	94.3
	10-30-79	0.05	22.4

Measurement of suspended sediments were collected during the Danielson study. Below are the results from selected tributaries of Huntington Creek.

Table 7-8 Suspended Sediments, Huntington Creek Tributaries

Stream	Site No.	Date	Concentration	Tons/day
Huntington Creek (gauging station 0931800)	88	08-13-78	104	27
		11-17-78	72	2.5
		06-13-79	114	6
		08-07-79	44	15
Crandall Canyon (gauging station 09317919)	51	08-12-78	49	0.14
		11-18-78	60	0.08
		06-14-79	15	0.41
		08-06-79	56	0.15
Tie Fork Canyon (gauging station 09317920)	67	08-13-78	12	0.03
		11-18-78	57	0.12
		06-14-79	38	0.68
		08-06-79	66	0.17
Bear Creek	81	10-25-78	8,860	1.9
		06-14-79	2,140	4.0
Deer Creek	87	06-14-79	609	3.1

* Stream flow measurements are taken from Danielson, 1981, see references

Effects of Mining on Surface Water

The operation of Bear Canyon Mine by C. W. Mining is expected to have only a very minimal effect on surface water on the area. The quality of Bear Creek before passing through the mine plan area is poor. Generally, as the excess mine water is discharged into Bear Creek; the surface water quality is improved significantly after passing through the mine site. The potential impacts to surface waters are discussed in Appendix 7-J, section 9.1.2. The greatest potential impact of mining operations is probably an increase in sediment loading to Bear Creek. Controls and diversion structures have been constructed to prevent sediment-laden water from disturbed area from mixing with local surface water, to minimize the mining impacts on the receiving stream waters.

Surface Water Site Selection

All perennial streams inside the permit area start within the permit area. Because of this the major groundwater sources feeding them are monitored. Surface monitoring sites have been selected at all major confluences and at other points of interest. Additionally sites were selected in all perennial streams as close as possible, based on accessibility, to the edge of the permit boundary to detect any of site impacts. The parameters tested for and the schedule followed are the ones determined to be adequate based on the study found in Appendix 7J. Three years of baseline data will be collected which exceeds the minimum required by law. The Division recommended list for baseline parameters will be followed which exceeds the minimum required by law. Additionally every five years baseline parameters will be collected. The rest of the time field readings will be collected which includes flow data and enough parameters to determine an impact. These sites are listed in Table 7-14.

724.300 Geologic Information

Geologic information for use in determining the probable hydrologic consequence of mining operations upon the quality and quantity of surface and ground water, whether reclamation can be accomplished, and whether the proposed operations have been designed to prevent material damage to the hydrologic balance outside the permit area is discussed in detail in Chapter 6 Geology (R645-301-624) and under numerous headings in this chapter.

724.400 Climatological Information

The climate of the Bear Canyon Mine area is typical of subalpine areas in the central region of Utah. In general, the summer season is short with maximum temperature readings (°F) in the 80's and minimum readings in the 40's. Fall and spring seasons are erratic in nature, with snow precipitation occurring as early as September and as late as the first part of June. Winters in this subalpine area are often severe, with recorded temperatures of -20°F or below at times. Major snowfalls can occur in the months of December, January, and February. Snow frequently remains on the ground from November until April in depths varying up to 6 ft. Winds are generally light to moderate, with average speeds below 21 m.p.h. The prevailing wind direction within the area of the mine site is from the southwest. Winds are generally parallel to the canyon, except during storm periods. Wind speed varies from canyon to canyon.

The estimated annual background total suspended particulate (TSP) in rural, central Utah is approximately 20 $\mu g/m^3$ (AeroVironment, 1977). Because of the proximity to existing mines, background TSP could be higher than the average background total for typical rural areas.

724.411 Precipitation

Precipitation varies greatly in the vicinity of the permit area due to the Manti-Lasal Mountain Range. Local factors affecting precipitation in the area are altitude, topography, and geographic location relative to the west-to-east storm track. The normal annual precipitation at the center of the permit area is approximately 8 to 10 inches greater than it is near the office area.

The nearest weather monitoring station is at Hiawatha, located about 5 miles Northeast of the center of the permit area. The annual precipitation recorded at the Hiawatha station is 13.18 inches Table 7-9 shows the precipitations recorded from 1916 to 1975. An isohyetal map from the Hydrologic Atlas of Utah shows an annual precipitation of 22 inches at the center of the permit area. (This is the source of the discrepancy referenced in the OSM completeness determination.) Approximately 16 inches, or 73%, of this precipitation occurs as snow from October to April. The other 6 inches, or 27%, occurs from May to September as rainfall. Snow accumulation averages 4.5 ft. A maximum snow depth of 6 ft is to be expected.

In mid-1991, a precipitation gauge was installed at the Bear Canyon Mine, located at the Scale house. Table 7-10 shows the average monthly precipitation from 1992 through 1995. Additional precipitation data for the surrounding area is shown in Appendix 7-N, *Hydrogeologic Evaluation*.

724.412 Wind Direction and Velocity

In general, winds are light to moderate, with average speeds below 20 mph[1]. Wind speed varies from canyon to canyon. At the Bear Canyon Portal area, the average wind speed is estimated at 10 mph, directed from west-southwest. Tornadoes are very rare, but strong winds may occur, particularly in these mountain passes and canyons. The highest gust in the vicinity of the mine site is expected to be more than 100 mph. The gust would occur under extremely unstable conditions with active fronts. See Appendix 7-P.

[1]Arlo Richardson, Utah State Climatologist, Utah State University.

724.413 Temperature

Temperature is seasonally variable and highly influenced by elevation. January temperatures vary from a mean minimum of 13°F to a mean maximum of 30°F. July temperatures vary from a mean minimum of 54°F to a mean maximum of 82°F (Jeppson et al., 1968). Similar temperature ranges are recorded at the Hiawatha Station. Table 7-11 shows the temperatures recorded between 1922 and 1975. The average annual temperature is 45°F. July is the warmest month (an average of 69°F) and January is the coldest (an average of 23°F). Wide daily temperature ranges are caused by relatively strong daytime warming and rapid nighttime cooling.

724.420 Evaporation and Relative Humidity

The potential evaporation is about 40 inches/yr. Transpiration is less than 18 inches/yr. The relative humidity ranges from a summer average of 45% to a winter average of 85%.

Table 7-9 Precipitation Totals - Hiawatha Station (inches)

Month	Mean	Greatest Daily	Year	Snow Mean	Snow Maximum Monthly	Snow Year
January	0.87	0.92	1944	21.3	59.0	1969
February	0.98	1.29	1923	12.8	47.0	1969
March	0.99	1.20	1935	9.7	39.5	1952
April	0.91	1.33	1944	4.0	22.0	1965
May	1.05	2.00	1922	2.0	25.0	1964
June	1.04	2.14	1941	0.2	1.0	1925
July	1.22	1.20	1973	0.0	0.0	-
August	1.92	2.05	1946	0.0	0.0	-
September	1.26	1.73	1961	4.2	11.0	1965
October	1.20	1.54	1941	1.3	14.0	1961
November	0.73	1.35	1943	6.6	30.5	1951
December	1.01	1.53	1916	13.0	50.5	1951
Annual	13.18	2.14	June 1941	74.5	59.0	January 1969

Station:	Hiawatha	Longitude:	110° 01'
Elevation:	7,220 ft	Latitude:	39° 29'
Period of Record:	1916 – 1975		

Table 7-10 Precipitation Totals - Bear Canyon Station (inches)

Month	Mean	Greatest Daily	Year
January	0.51	0.43	1993
February	0.53	0.31	1994
March	1.00	1.22	1993
April	1.11	0.59	1995
May	1.42	0.67	1992
June	0.39	0.33	1995
July	0.62	0.69	1992
August	2.00	1.01	1995
September	0.78	0.52	1994
October	0.99	0.47	1992
November	0.35	0.26	1994
December	0.34	0.30	1995
Annual	10.04	1.22	March 1993

Station:	Bear Canyon Mine	Longitude:	111° 05' 40"
Elevation:	7,092 ft.	Latitude:	39° 24' 30"
Period of Record:	1992 – 1995		

Table 7-11 Temperatures (°F)

Month	Means			Extremes			
	Daily Maximum	Daily Minimum	Monthly	Record Highest	Year	Record Lowest	Year
January	32.2	13.5	22.9	59	1971	-16	1971
February	36.2	17.4	26.8	59	1971	-18	1933
March	43.9	22.7	33.9	68	1966	-10	1964
April	54.5	31.1	42.9	80	1928	7	1975
May	64.8	39.9	52.3	86	1936	18	1965
June	74.4	48.9	61.7	93	1961	26	1943
July	82.0	56.2	69.1	95	1931	35	1968
August	79.0	54.5	65.4	93	1940	33	1968
September	71.3	46.6	59.0	92	1934	19	1965
October	59.0	36.6	47.8	78	1933	10	1972
November	43.5	24.1	33.8	63	1975	-2	1931
December	34.4	16.1	25.0	58	1959	-12	1924
Annual	56.3	34.0	45.1	95	July 1931	-18	Feb 1933

Station: Hiawatha
Elevation: 7,220 ft.
Period of Record: 1922 – 1975

Longitude: 110° 01'
Latitude: 39° 29'

724.500 Supplemental Information

Rule R645-301-728 discusses the probable hydrologic consequences of existing and proposed mining operations.

724.700 Alluvial Valley Floor

This does not apply.

R645-301-725 Baseline Cumulative Impact Area Information

A copy of the Cumulative Hydrologic Impact prepared by the Division can be found in Appendix 7-L.

R645-301-726 Modeling

Some modeling, interpolation and statistical techniques are utilized in this chapter; however, actual surface and ground water information is predominately provided.

R645-301-727 Alternate Water Source Information

No alternate water source is needed since we do not expect to impact any current water sources as explained in R645-301-724.100 and R645-301-724.200.

R645-301-728 Probable Hydrologic Consequence Determination

See Appendix 7J.

728.200 Baseline Information

This is discussed in Appendix 7J in sections 3 through 7 of the first Mayo report, and Appendix 7M and 7N.

728.310 Adverse Impacts to the Hydrologic Balance

See section 1 of the second Mayo report in Appendix 7J.

728.320 Acid/Toxic Forming Material

See section 2 of the second Mayo report in Appendix 7J.

728.330 Impacts of Proposed on:

728.331 Sediment Yield; See section 3 of the second Mayo report in Appendix 7J.
728.332 Water Quality; See section 4 of the second Mayo report in Appendix 7J.
728.333 Stream Flow Alteration; See section 5 of the second Mayo report in Appendix 7J.
728.334 Water Availiabity; See section 6 of the second Mayo report in Appendix 7J.

728.340-350 Affects on Water Resources and Water Rights

See section 7 of the second Mayo report in Appendix 7J.

R645-301-729 Cumulative Hydrologic Impact Assessment

See Appendix 7-L.

R645-301-730 Operation Plan

R645-301-731 General Requirements

731.100 Hydrologic Balance Protection

Water Consumed During Production

Continuous Miner

Inherent Coal Moisture = 6% Mine Run Moisture = 7% Max Yearly Production = 400,000 tons

water loss = ((0.07-0.06)*400,000 Tons)*(2,000 lbs/1 TON)*(1 gal/8.33 lbs)*(1acre-ft/325,850 gal)

water loss = 2.95 acre-ft/year

Longwall

Inherent Coal Moisture = 6% Mine Run Moisture = 12% Max Yearly Production = 2,100,000 tons

water loss = ((0.12-0.06)*2,100,000 Tons)*(2,000 lbs/1 TON)*(1 gal/8.33 lbs)*(1acre-ft/325,850 gal)

water loss = 92.84 acre-ft/year

Surface Dust Suppression

Average water used for road watering = 600,000 gallons Average water used for stockpiles = 2 gallons/Ton

water loss = 600,000+(2 gal/Ton*2,500,000 Tons) = 6,043,371 gal/yr = 18.55 acre-ft/year

Ventilation Loss

p_b = barometric pressure = 29.88 in. HG t_d = dry bulb temperature = 40°F ,45°F

t_w = wet bulb temperature = 38°F , 43°F Q = Ventilation quantity = 160,250 inlet, 191,540 outlet

p_s'=sat. vapor press., wet bulb (in. Hg) = $0.18079*e\text{^}((17.27*t_w - 552.64) / (t_w +395.14))$ = 0.023, 0.279

p_v= actual vapor pressure (in. Hg) = $p_s' - [((p_b - p_s')*(t_d - t_w)) / (2800-1.3*t_w))]$ = 0.208, 0.257

W = specific humidity (lb/lb dry air) = $0.622*(p_v / (p_b-p_v))$ W_I =0.0043 W_E =0.0054

p_a =partial pressure of air (in. Hg) = $p_b - p$ = 29.67 inlet, 29.62 oulet

v = specific volme (ft^3/lb) = $(0.754 * (t_d +460)) / p_a$ = 12.71 inlet, 12.85 oulet

G = weight flow-rate (lb/h) = 60 * Q / v = 756,756 inlet, 894,071 outlet Average = 825,414

water loss =G (lb/h)*$(W_E - W_I)$* .016018 (ft^3/lb)*8766 (h/yr) / 43560(ft^3/acre-ft) = 2.77 acre-ft/year

Water Produced – Antiquity water produced in the Bear Canyon #1 Mine

Average Flow = 30 gpm

Yearly water generated = (30gpm) * (60 min/1 hour) * (24 hour/ 1 day) *(365 day/ 1 year) = 15,768,000 gallons/year

water gain = 15,768,000 gallons/year * (1acre-ft/325,850 gal) = 48.39 acre-ft/year

Total Maximum Water Loss = 2.95 + 92.84 + 18.55+ +2.77-48.39 = 69 acre-ft/year

Affects of Mining on Groundwater Balance

Mining operations in the permit area will be confined to the coal bearing strata within the basal part of the Blackhawk formation. The coal strata are generally dry throughout most of the permit area, with the Tank Seam being dry throughout the entire property, and are part of an undeveloped aquifer system, which consists of a series of generally discontinuous perched water zones within the Blackhawk formation. Overlying formations are not uniformly saturated. The Star Point Sandstone is unsaturated in the Southern and Eastern parts of the permit area, and saturated in all three tongues on the Northwestern end of the permit area. The potential groundwater impacts are discussed in detail in Appendix 7-J, section 9.0. The potential impacts can be categorized into two basic sections: 1.) Potential impacts to groundwater quantity and 2.) Potential impacts to groundwater quality.

Quantity

Mining affects on water quantities consist of interceptions of local perched zones, and the interception of a larger perched aquifer at the North end of the Blind Canyon Seam workings. Investigations have shown that this aquifer is not hydraulically connected to Big Bear or Birch Spring (Appendix 7-N), so dewatering of this aquifer will have no impact on the quantity of these springs. These waters are collected in sumps within the mine and either diverted for culinary water and dust control or it is discharged into Bear Creek. Groundwater surveys are conducted and submitted annually to the Division. Groundwater is also removed as moisture within the coal itself, as evaporation in the mine ventilation air discharge, and in dust suppression.~~.~~ ~~As discussed in the PHC, the estimated volume of water removed in this manner is 22 acre-feet per year.~~ A calculation of maximum yearly water loss anticipated is included below.

The affects of subsidence in the permit area, on regional or local groundwater flow, are expected to be minor and of short duration. Localized diversions or interceptions of short duration only are expected due to the plastic flow of shaley units and to both development and tightening of existing fractures which occur due to unbalanced compressive-tensile forces associated with subsidence. The reclamation plan proposes to control post-mining subsidence which is expected to be a maximum of ~~5.5~~10 feet assuming all three seams are mined, with no subsidence to occur in a varying 100 to 200 ft wide corridor from outcrop areas and permit boundary areas~~, as well as under escarpments~~.

In the portion of Federal Lease U-024316 to be permitted, mining will take place in the ~~Tank~~Blind Seam only, ~~which will limit any subsidence to a maximum of 1.9 feet.~~ In the event mining reaches far enough ~~North~~ to mine at an elevation below Bear Creek, an adequate barrier will be left to completely prevent any impact on Bear Creek. This barrier is shown on Plate 5-3 and described in Appendix 5-C.

Quality

The potential impacts to water quality include contamination of water due to rock dust usage, abandoned equipment, the usage of hydrocarbons, and contamination from road salting. These potential water quality impacts are discussed in detail in Appendix 7-J, Section 9.0 (PHC) and Appendix 7-P.

Rock dust which is used for the suppression of coal dust may potentially impact the groundwater flowing through the mine by the dissolution of the rock dust constituents into the water. This could result in increase concentrations of TDS or sulfates. Gypsum rock dust has been known to result in high TDS concentrations; therefore Co-Op has implemented the use of

Rock dust which is used for the suppression of coal dust may potentially impact the groundwater flowing through the mine by the dissolution of the rock dust constituents into the water. This could result in increase concentrations of TDS or sulfates. Gypsum rock dust has been known to result in high TDS concentrations; therefore Co-Op has implemented the use of limestone rock dust. Mine water discharged into Bear Creek is monitored for TDS, as well as the in-mine water monitoring wells, to ensure increased concentrations do not result for the mining activities.

Hydrocarbons (in the form of fuels, greases, and oils) are stored and used on-site for the mining equipment. Spillage of these materials could potentially contaminate the groundwater in the permit area. Section 9.0 of the PHC (Appendix 7-J) discusses in detail the program, which C. W. Mining has implemented to prevent contamination of the groundwater from these sources. Road salting is also discussed. Abandoned equipment is discussed in Appendix 7-Q.

Mitigation and Control Plans

No treatment of groundwater occurrence or other control measures in the present mine have been required. Interference of the groundwater regime has consisted of interception of local perched zones within the Blackhawk formation, with the significant portion of the flow coming from a sandstone channel located at the North end of the Blind Canyon Seam workings.

No treatment of groundwater occurrence or other control measures have been required or are expected to be required for the permit area. See the discussion on potential impacts in Appendix 7-J.

As discussed in Appendix 7-J, section 9-1, hydrocarbons in the form of oil and fuel are stored at the mine site. A spill prevention control and counter measures plan is maintained onsite-outlining controls to prevent and mitigate any hydrocarbon spills. Within six months of the implementation of the Wild Horse Ridge facilities construction, this plan will be updated to reflect the controls for the new facilities. If any state appropriated water rights are impacted in the future C. W. Mining will meet with the water right holder and the Division and develop a site specific water replacement plan.

Water Monitoring

Groundwater Monitoring Plan

Monitoring activities are designed to determine water levels, discharge and water quality fluctuations in relevant aquifers or groundwater occurrences in the mine area. Data is collected from mine sumps, from monitoring wells within the mine, observation wells on the surface, and springs. The objectives are to identify potential impacts during and after mining and, provide continuing data on the areas aquifer characteristics and groundwater occurrences. A recommended water-monitoring program is included in Appendix 7-J, section 10.0. The current approved water monitoring program is shown in Table 7-14.

Springs below the mine will be sampled to determine discharge and water quality parameters and their possible variation with time. These springs include SBC-14, Big Bear Springs, COP Development Springs, and Birch Springs (Plate 7-4). Periodic checks will be made of the mine area to determine any impact not currently expressed at the surface. This data will be used to estimate seasonal fluctuations, aquifer recharge and consistent long-term changes and to ensure that no impacts occur. Springs above the mine will be monitored for field parameters, since the potential for impact to these springs is quantity rather than quality. SBC-9A and SBC-4 will be monitored for lead quality.

Groundwater monitoring will follow the ground water sampling guidelines as shown in Table 7-12 using the water quality parameter list in Table 7-13. These tables follow the recommendations presented in Appendix 7-J. New significant occurrences within the present permit area will be promptly included in the sampling program, as specified by state requirements. Operational ground water monitoring will continue through reclamation to Bond Release.

The sampling matrix for each of the existing monitoring stations during the operational phase of mining is included in Table 7-14. ~~No baseline data is available for SBC-17, but will be collected in 2000 and 2001, prior to mining occurring within the vicinity of this spring.~~ Baseline samples were collected for SBC-14, SBC-15, SBC-16, SBC-17, MW-114 and MW-117 in 2001. Three years of baseline will be collected on all additional sites added after 2001.

Temporary Drill Hole Seals. Within 30 days of completion, drill holes utilized for groundwater monitoring will be sealed in a nonpermanent fashion by installing PVC surface casing with a threaded cap for access.

Temporary Drill Hole Seals. Within 30 days of completion, drill holes utilized for groundwater monitoring will be sealed in a nonpermanent fashion by installing PVC surface casing with a threaded cap for access.

Annual Report. An Annual Report evaluating all data collected for the year will be submitted to DOGM as required.

Quarterly Data Submission. All water monitoring data will be submitted to DOGM on a quarterly basis within 90 days or less of quarterly sampling collection.

DH-1A, DH-2, DH-3. Three observation wells, DH-1A, DH-2, DH-3, were installed in 1992 (Plate 7-4). These wells are for the collection of piezometric surface and water quality data from the Spring Canyon tongue of the Star Point Sandstone, and are located such as to determine the extent or occurrence of groundwater within the depths of potential impact of the mining activities on the groundwater regime. Construction and Development of these wells are discussed in Appendix 7-N. In 1993 DH-3 was abandoned and was replaced by DH-4, shown on Plate 7-4.

Groundwater encountered in these wells will be sampled as specified above along with the other locations and used to correlate with the water quality data from Bear Springs, COP Development Springs, Huntington Spring, and Birch Springs to provide a check on estimates of groundwater contamination. These springs were selected since their flow is the sole use of groundwater to be possibly affected by mining activities in the permit area. Discussion of initial data gathered in 1992 from the wells is found in Appendix 7-J (PHC) and Appendix 7-N.

Table 7-12 Ground Water Sampling

	Baseline Monitoring	Operational Monitoring	Post-mining Monitoring
Type of Sampling site	Springs, In-Mine Flows, Boreholes, Observation Wells.	Springs, In-Mine Flows, Boreholes, Observation Wells.	Springs, Observation Wells, Mine discharge points.
Field Measurements and Parameters (Table 7.1-7)	Water levels and/or flow and water quality	Water levels and/or flow and water quality	Water levels and/or flow and water quality
Sample Frequency Each site	Quarterly Adequate to describe seasonal variation. Monthly recommended for more accurate description of seasonal variation.	Quarterly samples springs and wells; In-mine flows at initial interception, quarterly after 1st 30 days until diminished. From sumps and/or mine discharge points quarterly or as required by UPDES.	Quarterly based on potential impact; or once per annum (spring sampling at low flow).
Sampling Duration	Three ~~Two~~ years (~~one complete year of data before submission of PAP~~Prior to mining in the area).	Every year until two years after surface reclamation activities have ceased. Sites will be monitored 4 times a year.	Until termination of bonding.
Type of Data Collected and Reported	Wells and Boreholes: Water quality, water level of flow logs, collar elevation; ground elevations; screened interval; formation where completed; depth. Springs: Water quality, location, and flow.	Wells and boreholes: Water quality, water level or flow. Springs: Flow and water quality with one sample taken at low flow.	Wells and Boreholes: Water quality, water level or flow. Springs: Flow, water quality with one sample taken at low flow. Phase I: Whether pollution of surface and subsurface water is occurring, the probability of future occurrence, and estimated cost of abatement. Phase II: After revegetation has been established and contributing suspended solids to streamflow or runoff outside the premit area is not excess of the requirements set by UCA 40-10-17(j) of the Act and by R645-301-751. Phase III: Until reclamation requirements of the Act and the permit are fully met.
Comments	Springs and seeps should be measured from source at high and low flow periods.	During the year preceding re-permitting. Springs, one water quality sample at low flow for baseline parameters. Other sites, one sample for baseline parameter.	

Table 7-13 Ground Water Quality Parameter List

Field Measurements:

*	-	Water Levels or Flow
*	-	pH
*	-	Specific Conductivity (umhos/cm)
*	-	Temperature (C)

Laboratory Measurements: (mg/l) (Major, minor ions and trace elements are to be analyzed in dissolved form only.)

*	-	Total Dissolved Solids	
*	-	Total Hardness (as $CaCO_3$)	
	-	Aluminum (Al)	
	-	Arsenic (As)	
*	-	Carbonate (CO_3^{-2})	
*	-	Cation-anion balance	
	-	Boron (B)	
*	-	Bicarbonate (HCO_3^-)	
	-	Cadmium (Cd)	
*	-	Calcium (Ca)	
*	-	Chloride (Cl^-)	
	-	Copper (Cu)	
*	-	Iron (Fe)	(Total and Dissolved)
†	-	Lead (Pb)	
*	-	Magnesium (Mg)	
*	-	Manganese (Mn)	(Total and Dissolved)
	-	Molybdenum (Mo)	
	-	Nitrogen: Ammonia (NH_3)	
	-	Nitrite (NO_2)	
	-	Nitrate (NO_3^-)	
*	-	Potassium (K)	
	-	Phosphate (PO_4^{-3})	
	-	Selenium (Se)	
*	-	Sodium (Na)	
*	-	Specific Conductivity (umhos/cm)	
*	-	Sulfate (SO_4^{-2})	
	-	Zinc (Zn)	

Sampling Period:
- Baseline

*Operational, Post-mining

†Quarterly for site SBC-9A and SBC-4

Table 7-14 Water Monitoring Matrix: Operational Phase of Mining

Location	Jan	Feb	Mar	Apr	May	June	July	Aug[3]	Sept	Oct	Nov	Dec
Streams												
BC-1 (Upper Bear Creek)		oper			oper	field	field	oper.	field	oper		
BC-2 (Lower Bear Creek)		oper			oper	field	field	oper.	field	oper		
BC-3 (Lower Rt Fork Bear Creek)		oper			oper	field	field	oper.	field	oper		
BC-4 (Upper Rt Fk. Bear Creek)		oper			oper.	field	field	oper.	field	oper		
CK-1 (Upper Cedar Creek)		oper			oper.	field	field	oper.	field	oper		
CK-2 (Lower Cedar Creek)		oper			oper.	field	field	oper.	field	oper		
MH-1 (Lower McCadden Hollow Creek)					field[5]		field	field		field		
MH-2 (Upper McCadden Hollow Creek)					field[5]		field	field		field		
FC-1 (Lower Left Fork Fish Creek)[7]					field[5]		field	field		field		
FC-2 (Lower Right Fork Fish Creek)[7]					field[5]		field	field		field		
FC-3 (Right Fork Fish Creek Property Line)[7]					field[5]		field	field		field		
FC-4 (Upper Right Fork Fish Creek)[7]					field[5]		field	field		field		
FC-5 (Mud Spring)[7]					field[5]		field	field		field		
FC-6 (Upper Left Fork Fish Creek)[7]					field[5]		field	field		field		
FC-7 (Water Right Upper LF FC)					field[5]		field	field		field		
FC-8 (Water Right Upper LF FC)					field[5]		field	field		field		
Springs												
SBC-3 (Creek Well)		oper			oper			oper.		oper		
SBC-4 (Big Bear Springs)[4]		oper			oper			oper.		oper		
SBC-5 (Birch Spring)[4]		oper			oper.			oper.		oper		
SBC-9A (Hiawatha Seam)		oper			oper			oper		oper		
SBC-12 (16-7-13-1)					field.[5]		field	field		field		
SBC-14 (WHR-6)		oper			oper.			oper.		oper		
SBC-15 (WHR-5)					field[5]		field	field		field		
SBC-16 (WHR-4)[6,7]					field[5]		field	field		field		
SBC-16A[7]					field[5]		field	field		field		
SBC-16B[7]					field[5]		field	field		field		
SBC-17 (16-7-24-4)		oper			oper.			oper.		oper		
SBC-18 (WHR-2)[7]					field[5]		field	field		field		
SBC-20 (16-8-16-4)[7]					field[5]		field	field		field		
SBC-21 (16-8-18-1)[7]					field[5]		field	field		field		
SBC-22 (Stockwater Trough)					field[5]		field	field		field		
SBC-23 ((FBC-12)					field[5]		field	field		field		
SCC-1 (16-8-20-1					field[5]		field	field		field		
SCC-2 (16-8-15-5)[7]					field[5]		field	field		field		
SCC-3 (Mohrland Portal)					field[5]		field	field		field		
SCC-5 (16-8-7-3)					field[5]		field	field		field		
SMH-1 (FBC-6)					field.[5]		field	field		field		
SMH-2 (FBC-5)					field[5]		field	field		field		
SMH-3 (FBC-13)					field.[5]		field	field		field		
SMH-4 (FBC-4)					field[5]		field	field		field		
SMH-5 (Stockwater Trough)					field[5]		field	field		field		
Wells												
SDH-2 (Well, Sec. 11, T16S, R7E)					level[5]		level	level	level	level		
SDH-3 (Well, Sec. 10, T16S, R7E)					level[5]		level	level	level	level		
MW-114 (Well, Sec 18, T16S, R8E)					level[5]		level	level	level	level		
MW-117 (Well, Sec 12, T16S, R8E)					level[5]		level	level	level	level		

Notes:
1. See Tables 7-13 and 7-17 for listing of water quality monitoring parameters.
2. oper. = operational base. = baseline
3. Baseline parameters taken in August of year 5 prior to each permit renewal.
4. SBC-4 and SBC-5 shall also be tested for oil and grease.
5. First sample to be taken in May or June, when Gentry Mountain is accessible.
6. A comment will be made regarding the level of the pond feeding the spring
7. Weekly monitoring to begin one month prior to mining in area and continue until one month after. Monthly monitoring will then be done for an additional six months.

Table 7-14A Surface Water Monitoring Matrix: Baseline Collection

Site Name	Site Description	Baseline Monitoring Start Date
BC-1	Upper Bear Creek	September 2, 1980
BC-2	Lower Bear Creek	September 2, 1980
BC-3	Lower Right Fork Bear Creek	January 5, 1987
BC-4	Upper Right Fork Bear Creek	February 29, 2000
CK-1	Upper Cedar Creek	June 9, 1994
CK-2	Lower Cedar Creek	June 9, 1994
MH-1	Lower McCadden Hallow Creek	July 31, 1991
MH-2	Upper McCadden Hallow Creek	May, 2007
FC-1	Lower Left Fork Fish Creek	June 9, 1994
FC-2	Lower Right Fork fish Creek	July 31, 1991
FC-3	Right Fork Fish Creek Property	May, 2007
FC-4	Upper Right Fork Fish Creek	May, 2007
FC-5	Right Fork Fish Creek Below Mud	May, 2007
FC-6	Upper Left Fork Fish Creek	May, 2007
FC-7	Water Right Upper LF Fish Creek	May, 2007
FC-8	Water Right Upper LF Fish Creek	May, 2007

Notes: 1. See Tables 7-13 and 7-17 for listing of water quality monitoring parameters.
2. See Table 7-14 for specific months that the sites will be monitored in.

Table 7-14B Ground Water Monitoring Matrix: Baseline Collection

Site Name	Site Description	Baseline Monitoring Start Date
SBC-3	Bear Creek Well	January 5, 1987
SBC-4	Big Bear Spring	January 5, 1987
SBC-5	Birch Spring	July 24, 1986
SBC-9A	Bear Canyon #1 Mine Portal	September 25, 2002
SBC-12	16-7-16-1	June 8, 1994
SBC-14	WHR-6	October 26, 1993
SBC-15	WHR-5	October 27, 1992
SBC-16	WHR-4	March 22, 1993
SBC-16A		May, 2007
SBC-16B		May, 2007
SBC-17	16-7-24-4	May 22, 2000
SBC-18	WHR-2	March 22, 1993
SBC-20	16-8-16-4	June 8, 1994
SBC-21	16-8-18-1	June 8, 1994
SBC-22	Stock Watering Trough	May, 2007
SBC-23	FBC-12	March 22, 1993
SCC-1	16-8-20-1	June 8, 1994
SCC-1	16-8-15-5	June 8, 1994
SCC-3	Mohrland Portal	January 19, 1979
SCC-5	16-8-7-3	June 8, 1994
SMH-1	FBC-6	October 13, 1992
SMH-2	FBC-5	October 13, 1992
SMH-3	FBC-13	August 29, 1993
SMH-4	FBC-4	October 13, 1992
SMH-5	Stock Watering Trough	May, 2007

Notes: 1. See Tables 7-13 and 7-17 for listing of water quality monitoring parameters.
2. See Table 7-14 for specific months that the sites will be monitored in.

Table 7-15 Past ~~and existing~~ monitoring sites

Site ID	Description	Status
Springs		
SBC-1	Under Ground Seep[1]	Dried up early 1988, and monitoring was discontinued.
SBC-2	Portal Well[2]	Dry from 1987. Caved in, lost (2) quarters and relocated in 1991.
~~SBC-3~~	~~Creek Well~~	~~Active~~
~~SBC-4~~	~~Huntington Spring~~	~~Active~~
~~SBC-5~~	~~Birch Spring~~	~~Active~~
SBC-6	COP Development Spring[3]	Dried up in 1987, with no flow through 2000. Monitoring discontinued in 2000.
~~SBC-12~~	~~Bear Creek Source (16-7-13-1)~~	~~Active~~
~~SBC-14~~	~~Right Fork Spring WHR-6~~	~~Active~~
~~SBC-15~~	~~Right Fork Spring WHR-5~~	~~Active~~
~~SBC-16~~	~~Fish Creek Spring WHR-4~~	~~Active~~
~~SBC-17~~	~~Upper Bear Spring 16-7-24-4~~	~~Active~~
~~SMH-1~~	~~MH Left Fork Spring (FBC-6)~~	~~Active~~
~~SMH-2~~	~~MH Water Trough (FBC-5~~	~~Active~~
~~SMH-3~~	~~MH/Trail Ridge Spring (FBC-13)~~	~~Active~~
~~SMH-4~~	~~MH Right Fork Spring (FBC-4)~~	~~Active~~
In-Mine Sources		
SBC-7	Sump #1	Dried up and discontinued in 2000.
SBC-8	Sump #2	Dried up and discontinued in 2000.
SBC-9	Sump #3[4 6]	Abandoned in 1999 due to retreat mining and replaced by SBC-13.
~~SBC-9A~~	~~Hiawatha Seam 1st North~~	~~Activated in Oct. 2002 when a borehole was drilled up to the old SBC9 site.~~
SBC-10	Sump #4	Flow first measured Dec. 1991. Monitoring initiated Jan. 1992. In July, 1995, retreat mining progressed passed this sump, making it inaccessible. Monitoring was discontinued in August 1995. Flows from this area have subsequently flowed through the pillared area and out of the 1st East pillared section.
SBC-11	Hiawatha Seam 1st North	Abandoned in January 2003
SBC-13	1st East Pillared Section[5]	Abandoned in April 2002 due to retreat mining and replaced by SBC-9A
Wells		
DH-1A	2nd W. Monitor Well	Abandoned in 2001 due to retreat mining.
DH-2	3rd W. Monitor Well6	Abandoned in 1999 due to retreat mining.
DH-3	1st E. Monitor Well6	Abandoned in 1993 due to retreat mining and was replaced by DH-4.
DH-4	3rd W. Bleeder Monitor Well6	Abandoned in 1999 due to retreat mining.
~~SDH-2~~	~~Well, Sec. 11, T16S, R7E~~	~~Active~~
~~SDH-3~~	~~Well, Sec. 10, T16S, R7E~~	~~Active~~
~~MW-114~~	~~Wild Horse Ridge Monitor Well~~	~~Active~~
~~MW-117~~	~~Gentry Mtn. Monitor Well~~	~~Active~~
MW-116	Gentry Mtn. Monitor Well	The side caved in and the well was lost

SDH-1, SDH-2, SDH-3. These three monitoring wells were installed in 1995 from the surface (Plate 7-4). These wells are completed in the Spring Canyon tongue of the Star Point Sandstone, with SDH-1 and SDH-2 located to monitor the potentiometric surface in conjunction with the DH wells discussed previously. SDH-3 was installed West of the Blind Canyon fault (western boundary of the permit area) in order to observe the relationship of the Spring Canyon aquifer on each side of the fault. Completion diagrams of these wells are included in Appendix 7-A. The initial baseline data is included in Appendix 7J-A. Based on these baseline levels, a potentiometric surface for the Spring Canyon aquifer was developed. This is shown in Appendix 7-J, Figure 13b, and on Plate 7J-2.

In 1996, SDH-1 well plugged and was lost while attempting to unplug the well. SDH-2 and SDH-3 are monitored for water levels as shown in Table 7-14.

MW-114, ~~MW-116,~~ MW-117. These ~~three~~Two wells were drilled in 1991 by Cyprus/Plateau, and are located North of the Wild Horse Ridge expansion area. Both~~All three~~ wells are located East of the Bear Canyon fault. MW-114 is located immediately North of and adjacent to the permit area. These wells were also completed in the Spring Canyon member of the Starpoint Sandstone. Baseline water levels for these wells are included in Appendix 7J-A, and well completion diagrams are included in Appendix 7-A. Water age dating and chemical information will be collected from these wells to verify that the hydrologic patterns in the Wild Horse Ridge area are consistent with the patterns discussed in the PHC which have been found in the existing permit area. This information will also be collected from any new wells installed within or adjacent to the Wild Horse Ridge area.

Additional Monitor Wells. A minimum of one additional drillhole will be installed in the northern portion of the Wild Horse Ridge area, shown as DH-5 on Plate 5-1C. If necessary, additional wells may be installed following the installation and evaluation of DH-5 in order to adequately characterize the groundwater aquifers of the lower Blackhawk and upper Star point formations. DH-5 and any additional drillholes will be tested using the same methodology, which was used in the previous in-mine wells, described in Appendix 7-N. The holes will then be completed as monitor wells in the same manner as described in Appendix 7-N.

Springs above the mine have also been selected based on the conclusion of Appendix 7J and 2006 field investigations that included regulating agencies and interested parties. Because these springs are above the coal seam water quality impacts are not a major concern, however flow quantity impacts are. Sites were selected because they were either major contributors to surface water systems, or they were springs that have been developed for beneficial use or have water rights on them. The major contributors to surface water systems are SMH-3, SMH-4, SBC-12, SBC-18, SBC-20, SBC-21, SCC-1, SCC-3, and SCC-5. Perennial portions of the streams feed by sites SCC-5, SCC-2, SBC-16, SBC-16A, SBC-16B, SBC-20, and SBC-21 will be undermined. Because of this these sites will be monitored for flow weekly starting one month prior to undermining and continuing until one month after undermining at which time they will be monitored monthly for six months before returning back to their normal monitoring schedule. The actual start time will be determined based on continual underground surveying that is required by MSHA. During the monitoring weekly reports will be sent to the Division via email. The ground water sites selected because they were developed or had water rights are SMH-1, SMH-2, SMH-5, SBC-15, SBC-16, SBC-16A, SBC-16B, and SBC-22.

Measuring the flow from springs and seeps is almost always difficult because flows tend to be dispersed and rarely concentrate into well-defined channels amenable to discharge measurement.
The most accurate method of measuring small discharges, and the method that will be used, is by observing the time required to fill a container of known capacity, or the time required to partly fill a calibrated container. The basic equipment is a stopwatch and a calibrated container.

Purchased pre-calibrated containers may be used or containers will be calibrated by either adding known volumes of water by increments and measuring the depth of water in the container, or by weighing the container with varying amounts of water in it, noting the depth in the container, and using the formula: $V = (W2-W1)/w$; where: V = volume of water in the container, $W2$ = weight of container with water, $W1$ = weight of empty container, and w = unit weight of water.

The basic field procedure will consists of interrupting the flow and collecting the water. Temporary earth dams may be constructed to divert the water through a small diameter pipe for capture. Or it may be possible to place a trough or half of a stove pipe against the spring or seep to carry the water to the calibrated container. Cloths, clay, or other materials will be used to temporarily seal cracks and force the water to go into the calibrated container. Where flows come out of the ground in a number of distinct sources or if they are scattered over a broad area, the results of several different measurements will be added together.

731.220 Surface Water Monitoring

In the past, C. W. Mining has monitored three stations on Bear Creek, one above (north) the mine plan area, one at the right-hand tributary (center) and one below the mine area (southwest). The monitoring location above the mining area is approx 3000 ft upstream from where the mine road crosses Bear Creek in the mine plan area. The monitoring location at the right-hand tributary of Bear Creek is located just above its confluence with the main Bear Creek. Two additional monitoring locations will be added to this tributary for mining in Wild Horse Ridge, one above the disturbed area (northeast), as well as a spring located in the drainage (SBC-14, see section 7.1). The monitoring location downstream is near the Ballpark topsoil storage pile. Monitoring stations are shown on Plate 7_4 and listed below. Monitoring points have also been added to the Fish Creek and McCadden Hollow drainages to monitor for water quantity impacts.

Streams

1. Upper Bear Creek	-	BC-1
2. Lower Bear Creek	-	BC-2
3. Lower Right Fork Bear Creek	-	BC-3
4. Upper Right Fork Bear Creek	-	BC-4
5. Lower McCadden Hollow Creek	-	MH-1
6. Fish Creek Left Fork	-	FC-1
7. Fish Creek Right Fork	-	FC-2
8. Fish Creek RF Property Line	-	FC-3
9. Upper Fish Creek Right Fork	-	FC-4
10. Fish Creek Past Mud Spring	-	FC-5
11. Upper Fish Creek Left Fork	-	FC-6
12. Upper Fish Creek LF Water Right	-	FC-7
13. Upper Fish Creek LF Water Right	-	FC-8
14. Upper Cedar Creek	-	CK-1
15. Lower Cedar Creek	-	CK-2
16. Upper McCadden Hollow Creek	-	MH-2

Surface monitoring will follow the surface water sampling guidelines as shown in Table 7-16, using the water quality parameter list in Table -16. Monthly sampling matrix for each of the existing monitoring stations are included in Table 7-14. Operational surface water monitoring will continue through reclamation to bond release. Three years of baseline will be collected on all new sites.

Table 7-16 Surface Water Sampling

	Baseline Monitoring	Operational Monitoring	Post-mining Monitoring
Type of Sampling Site	Surface Water Bodies.	Surface Water Bodies.	Surface Water Bodies.
Field Measurements and Parameters (Table 7.1-7)	Performed during water level/flow measurements.	Performed during water level/flow measurements.	Performed during water level/flow measurements.
Sample Frequency	Quarterly for lakes, reservoirs and impoundments (water level and quality); monthly flow measurements and quarterly water quality measurements (one sample at low flow and high flow each) for perennial streams. Monthly flow and water quality measurements during period of flow for intermittent streams. Sampling for ephemeral streams determined at pre-design conference.	Quarterly for lakes, reservoirs and impoundments (water level and quality); monthly flow measurements and quarterly water quality measurements (one sample at low flow and high flow each) for perennial streams. Monthly flow and water quality measurements during period of flow for intermittent streams. Sampling for ephemeral streams determined at pre-design conference.	Two per annum for perennial streams (high & low flow); two per annum during snowmelt and rainfall for intermittent streams.
Sampling Duration	~~Two~~ Three years (~~one complete year of data before submission of PAP~~Prior to mining in the area).	Every year until two years after surface reclamation activities have ceased. Sites will be monitored 4 times a year.	Every year until termination of bonding.
Type of Data Collected and Reported	Flow and/or water levels and water quality.	Flow and/or water levels and water quality.	Flow and/or water levels and water quality per operational parameters.
Comments	All field measurements should be performed concurrently with water level/flow measurements.	All field measurements should be performed concurrently with water level/flow measurements.	All field measurements should be performed concurrently with water level/flow measurements.
Additional Comments		For every fifth year preceding re-permitting, one sample at low flow and high flow each should be taken for baseline water quality parameters. The construction monitoring program will be conducted on a site-specific basis in addition to the operational monitoring.	

Table 7-17 Surface Water Quality Parameter List

Field Measurements:

	*	-	Water Levels or Flow	
	*	-	pH	
	*	-	Specific Conductivity (umhos/cm)	
	*	-	Temperature (C□)	
	*	-	Dissolved Oxygen (ppm) (perennial streams only)	

Laboratory Measurements: (mg/l)   (Major, minor ions and trace elements are to be analyzed in dissolved form only.)

#	*	-	Total Settleable Solids	
#	*	-	Total Suspended Solids	
	*	-	Total Dissolved Solids	
	*	-	Total Hardness (as $CaCO_3$)	
		-	Aluminum (Al)	
		-	Arsenic (As)	
		-	Boron (B)	
	*	-	Carbonate (CO_3^{-2})	
	*	-	Bicarbonate (HCO_3^-)	
		-	Cadmium (Cd)	
	*	-	Calcium (Ca)	
	*	-	Chloride (Cl^-)	
		-	Copper (Cu)	
	*	-	Iron (Fe)	(Total and Dissolved)
		-	Lead (Pb)	
	*	-	Magnesium (Mg)	
	*	-	Manganese (Mn)	(Total and Dissolved)
		-	Molybdenum (Mo)	
		-	Nitrogen: Ammonia (NH_3)	
		-	Nitrite (NO_2)	
		-	Nitrate (NO_3^-)	
	*	-	Potassium (K)	
		-	Phosphate (PO_4^{-3})	
		-	Selenium (Se)	
	*	-	Sodium (Na)	
	*	-	Specific Conductivity (umhos/cm)	
	*	-	Sulfate (SO_4^{-2})	
		-	Zinc (Zn)	
	*	-	Oil and Grease	
	*	-	Cation-Anion Balance	

Sampling Period:

-Baseline
*Operational, Postmining
#Construction

Flows will be determined by direct measurement (depth times width times 2/3 velocity), by use of portable or stationary weirs or flumes, or, whenever feasible, by timed filling of a unit volume container. Measurements will be taken by qualified personnel following standard procedures with calibrated instruments.

Stream monitoring sites were selected based on the conclusion of Appendix 7J and 2006 field investigations that included regulating agencies and interested parties.

Annual Report. An Annual Report evaluating all data collected for the year will be submitted to DOGM as required.

Quarterly Data Submission. All water monitoring data will be submitted to DOGM on a quarterly basis within 30 days following the end of the quarter.

Discharge Permit and Reporting. All discharge report forms filed to meet Government requirements will be submitted to DOGM in the quarterly Water Monitoring Report. A copy of the mine discharge permit is included in Appendix 7-B.

Post-Mining Portal Discharge. No gravity discharges are expected from the Bear Canyon No. 3 or No. 4 mines during or following reclamation. Any post-mining portal discharge that occurs will be monitored quarterly for operational parameters shown on Table 7-16. No water will be discharged into the mine during or following reclamation.

Undermining of Perennial Streams. There are two areas where perennial streams will be undermined. They are the upper reaches of the right fork and left fork of Fish Creek.

The left fork is fed by one watershed and several springs. FC-7 and FC-6 are surface monitoring sites in this watershed, however flow has only been observed at these points during major storm events and spring run-off. Most of the year the streams are dry above the confluence of the major springs feeding it. These springs are SBC-18, SBC-20, and SBC-21, with SBC-21 being the largest. The confluence of these springs with the main stream channel is inaccessible.

The right fork of Fish creek has two splits and is fed by three watersheds. The left split of the stream channel has base flow fed by SCC-5. This point also marks the start of the perennial section. The center split base flow is fed by SCC-2 which also marks the start of the perennial section for the center split. The right split is dry except during spring run-off or large storm events. However during wet years water may flow from site FC-5 (Mudd Spring). Because of this FC-5 was selected as the start of the perennial section of the right split. Monitoring site FC-4 was selected because it is the confluence of the three splits. Site FC-3 marks the property line between private and federal property, and site FC-2 was selected to monitoring off site impacts.

In these areas C. W. Mining will increase the monitoring of these sites to a weekly basis one month prior to mining in the area. This weekly monitoring will continue until one month after mining has left the area. Monitoring will then be reduced to once a month for an additional 6 months at which time it will resume its normal schedule. This increased monitoring will include the sites FC-2, FC-3, FC-4, FC-5, and SCC-2 for the right fork of Fish Creek, and FC-1, FC-6, SBC-16, SBC-16A, SBC-16B, SBC-18, SBC-20, and SBC-21 for the left fork of Fish Creek. The actual start time will be determined based on continual underground surveying that is required by MSHA. During the monitoring weekly reports will be sent to the Division via email.

731.300 Acid and Toxic Forming Materials

All provisions of R645-301-731.300 will be followed when dealing with acid or toxic forming material

.

731.400 Transfer of Wells

This was addressed in R645-301-731.210

731.500 Discharges

C. W. Mining's discharge permit is located in Appendix 7-B.

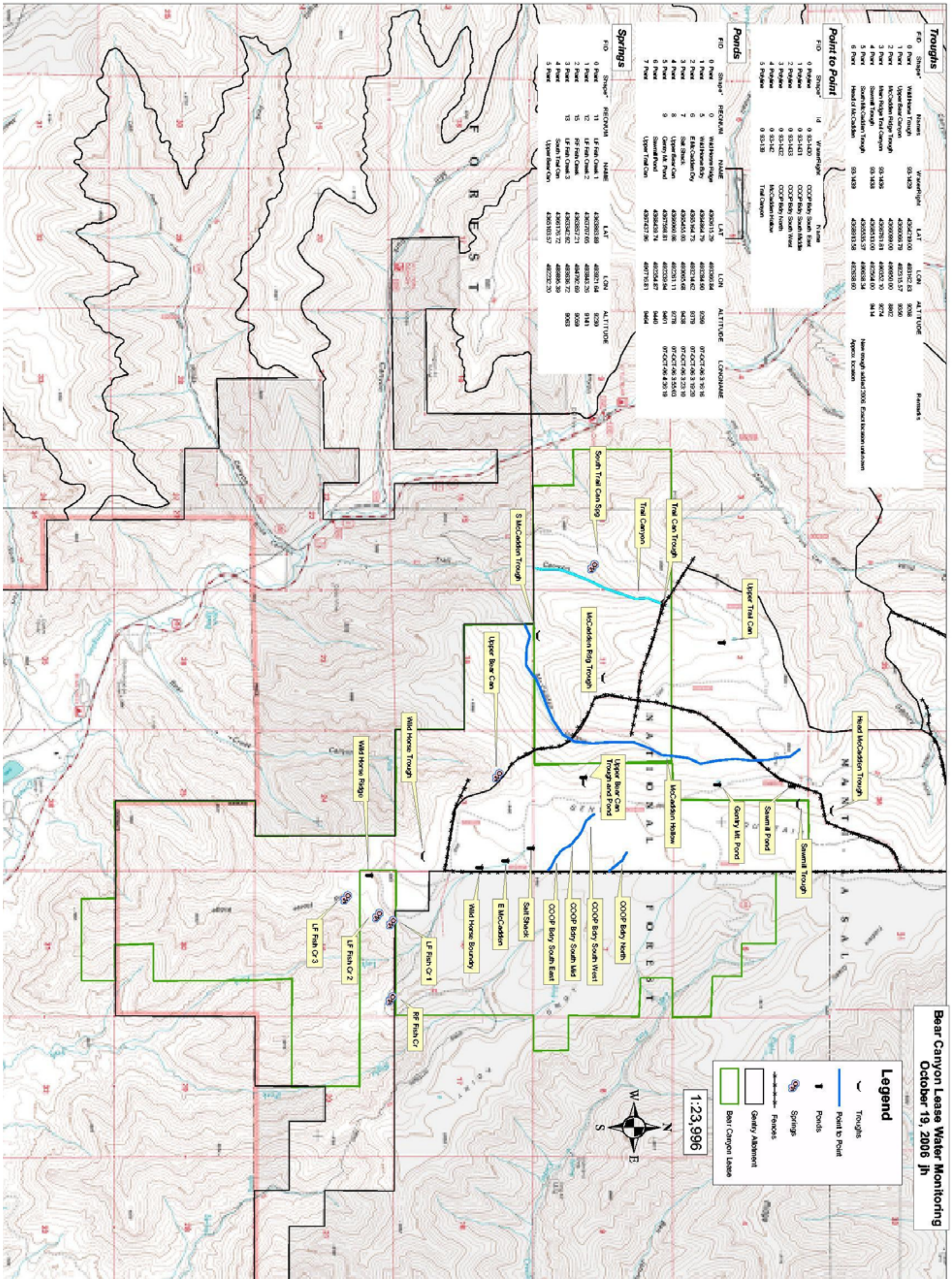
731.530 Water Rights and Replacement

If a state appropriated water supply is impacted by mining and/or mining related activities, C. W. Mining will replace it as required under R645-301-731.530 of the Utah State Code. Also in accordance with federal lease stipulation 21, if any water resource that has been identified for protection is impacted, C. W. Mining will replace the water resource.

Lease stipulation 21 requires the replacement of all water sources identified for protection. Figure 7-0 shows all water sources identified for protection. In accordance with the lease stipulation all sources identified will be replaced if impacted. Several of the sources identified are within the subsidence area and have been selected as water monitoring points as shown on Plate 7-4. The relationship between the water monitoring points and the names identified on figure 7-0 is outlined below.

F. S. Name	**Monitoring Name**	**Location**
LF Fish Cr 3	SBC-16	Inside subsidence zone
LF Fish Cr 2	SBC-16A	Inside subsidence zone
LF Fish Cr 1	SBC-16B	Inside subsidence zone
RF Fish Cr	SBC-18	Inside subsidence zone
Wild Horse Ridge	SBC-22	Inside subsidence zone
Wild Horse Boundary	none (Inspected with FC-6)	Outside subsidence zone
E McCadden	none (Inspected with FC-6)	Outside subsidence zone
Salt Shack	none (Inspected with FC-6)	Outside subsidence zone
S McCadden Trough	SMH-3 I	Outside subsidence zone
McCadden Rdg Trough	SMH-2	Inside subsidence zone
Upper Bear Can Trough	SMH-5	Outside subsidence zone
COOP Bdry South East	none (Inspected with FC-7)	Outside subsidence zone
COOP Bdry South Mid	none (Inspected with FC-7)	Outside subsidence zone
COOP Bdry South West	none (Inspected with FC-7)	Outside subsidence zone
COOP Bdry North	none (Inspected with FC-8)	Inside subsidence zone
McCadden Hollow	none (Inspected with SMH-4)	Inside subsidence zone
Gentry Mt Pond	none	Outside permit area
Sawmill Pond	none	Outside permit area
Sawmill Trough	none	Outside permit area
Head McCadden Trough	none	Outside permit area
Upper Trail Can	none	Outside permit area
Trail Can Trough	FBC-1	Outside subsidence zone
Trail Canyon	none	Outside subsidence zone
South Trail Can Spg	FBC-8	Outside subsidence zone

Figure 7-0 Forest Service Protected Water Resources



State appropriated water rights with points of diversions within the permit area are shown on Plate 7-12. All water resources identified for protection by the U. S. Forest Service are shown on Figure 5C-3. All water resources identified for monitoring are shown on Plate 7-4. These sites were identified in 2006 during several field surveys that included representatives from the following agencies at one or more of the surveys.

C. W. Mining Company
Utah Division of Oil Gas and Mining
State of Utah Water Rights Division
United States Forest Service
United States Department of the Interior - Bureau of Land Management
United States Department of the Interior - Office of Surface Mining
C. O. P. Coal Development Company
ANR Inc.
Huntington Cleveland Irrigation Company
Huntington Cattle Association

The primary water rights owners that may be impacted are C. O. P Coal Development, ANR Inc., United States Forest Service, and Huntington Cleveland Irrigation Company. Following is a discussion of the water usage of the entities and probable water replacement methods.

C. O. P. Coal Development

C.O.P Coal Development is the land owner and federal lease holder of all land being mined by C. W. Mining Company. They are a controlling entity of C. W. Mining in is much as they can dictate mining areas and methods through their lease requirements. Their water rights include stock watering, residential, and industrial. Stock water rights are associated with springs located above the mine within the subsidence area. These lands and water are leased to cattlemen who use the water for stock watering. The springs they use for residential use are located outside of the permit area near the old Trail Canyon Mine and inside the Bear Canyon #1 Mine. No impact is expected to these springs based on the investigation included in appendix 7J. These springs also provide the industrial water used for the mining operations conducted by C. W. Mining Company.

C. W. Mining has agreed to work with C. O. P Development on the replacement of any water rights.

ANR Inc.

ANR is affiliated with C. W. Mining in that they are both controlling entities of Hiawatha Coal Company. ANR Inc. is the private land owner and the federal lease holder for all lands mined by Hiawatha Coal. C. W. Mining is the LMU holder for all federal leases held by ANR Inc. Their water rights include stock watering, municipal, industrial, irrigation and residential. The only water rights located within the affected area are the ones used for stock watering. They also lease land and water to cattlemen.

C. W. Mining has agreed to work with ANR Inc. on the replacement of any water rights.

United States Forest Service

The U. S. Forest Service owns stock watering rights within the subsidence area. These water rights are used by wildlife and cattlemen who are leasing the land and water from the Forest Service.

Because of the nature of their use if these water rights were impacted the Forest Service would need the water to be restored to the original location. If the impact was a cracked stream or pond C. W. Mining would use pond liners, grouting, or other technologies available to repair the cracks. If the impact was a displaced spring C. W. Mining would install guzzlers, wells or other available technology to restore the water. Based on the experiences of other mines these methods have been acceptable.

Huntington Cleveland Irrigation Company

Huntington Cleveland Irrigation Company (HCIC) has water rights for stock watering, irrigation, and municipal uses. HCIC's points of diversion for their state appropriated water rights are located downstream of the subsidence area. Because of this, the stock-watering and irrigation uses for HCIC may not require replacement right at the source. They do require that the same quantity of water flows downstream to their points of diversion. For municipal use they have two springs of concern located outside, but near the permit area. These are Birch spring and Big Bear Spring. These springs are discussed in depth in Appendix 7J on pages 116 through 126. If these springs were impacted HCIC would require the same quantity of flow at a quality that meets drinking water standards.

If stock watering or irrigation water were impacted C. W. Mining would transfer or retire enough of their shares in HCIC to cover the lost water, or any course of action agreed upon between C. W. Mining and HCIC. Based on the study included in Appendix 7J showing that the springs are recharged locally, no impact to Birch Spring and Big Bear Spring is expected. However members of HCIC have expressed concern that the faults C. W. Mining will mine up against maybe recharge areas for these springs. In the extremely unlikely event that one of these springs is impacted, C. W. Mining would replace the lost flow with equivalent flow from existing springs which it currently holds water rights on. The replacement of either of the springs would most likely be development of new sources that meet the required standards, or the transfer of water from a source, that meets the standards, owned by C. W. Mining to the culinary water system impacted. Details regarding the replacement would be negotiated with HCIC and the municipalities impacted.

The requirement to replace water would be contingent upon the finding from Utah Division of Oil Gas and Mining that a state appropriated water supply or protected water resource was contaminated, diminished, or interrupted by underground coal mining and reclamation activities conducted after October 24, 1991.

731.600 Stream Buffer Zones

Anywhere that mining and reclamation activities are conducted within 100 feet of a perennial stream runoff and sediment control structures exist to protect water quality. These areas are designated as "Stream Buffer Zone do not Disturb".

731.700 Cross Sections and Maps

Plate 7-4 shows the water monitoring locations. Plates 7-1 show the hydrology of the disturbed area and water systems. Plate 7-10 shows in mine water surveys.

R645-301-732 Sediment Control Measures

All disturbed areas associated with mining and reclamation operations are protected by sediment control structures. Most of the larger areas are served by sediment ponds. Other disturbed areas, classified as Alternate Sediment Control Areas (ASCA's), utilize alternative methods of sediment control such as catch basins, silt fences, and interim revegetation. R645-301-742 and Appendix 7-K contain a detailed description of these methods.

732.100 Siltation Structures

Silt fences are used through the mine site. Their location and use is described in R645-301-742.100 and Appendix 7-K.

732.200 Sediment Ponds

This is addressed in R645-301-742.220

732.300 Diversions

This is addressed in R645-301-742.300

732.400 Road Drainages

All roads will be constructed, maintained and reconstructed to comply with R645-301-742.400

R645-301-733 Impoundments

Four sediment ponds are currently maintained within the permit area. All are temporary impoundments. No permanent impoundments are proposed. These are discussed in R645-301-742.220.

Plans and cross sections for sediment ponds A, B, C, and D can be found on Plates 7-2, 7-3, 7-6, and 7-11 respectably.

Appendix 7-E contains the slope stability analysis for sediment pond A. Appendix 7-I contains the sedimentation pond certification.

R645-301-734 Discharge Structures

C. W. Mining has five discharge points. One is in the Bear River above the scale house. The discharge structure consists of a pipe running from the storage tank to the river. The others are below the sediment ponds. These structures are detailed along with the sediment ponds.

R645-301-735 Disposal of Excess Spoil

C. W. Mining currently anticipates no excess spoil

R645-301-736 Coal Mine Waste

See R645-301-528.330 for a discussion of generation, storage, and disposal of coal mine waste.

R645-301-737 Non Coal Mine Waste

See R645-301-528.330 for a discussion of generation, storage, and disposal of non-coalmine waste.

R645-301-738 Temporary Casing of Wells

See Appendix 7-A and 7-N.

R645-301-740 Design Criteria and Plans

R645-301-741 General Requirements

The purpose of this section is to present the methodology used during hydrologic calculations for the Co-op Mine complex. The hydrologic calculations performed include runoff volumes and peak discharges, sediment storage calculations, existing sedimentation pond capacity, and existing diversion structure adequacy. The hydraulic design of permanent diversion structures, and adequacy of riprap is also addressed.

Runoff Calculations

Undisturbed watershed boundaries used to determine runoff conditions at the site are shown on Plates 7-5 and 7-5A. The disturbed area boundaries and the smaller undisturbed area boundaries are also shown in greater detail on Plates 7-1. Drainage areas are labeled according to whether or not it contributes to the sedimentation ponds (disturbed), or is diverted around the ponds (undisturbed). For example, AU-5 represents watershed 5 (U for undisturbed area).

Data obtained from these watersheds were input to a computer code called "Peak." to generate runoff hydrographs which were used for the design of drainage diversions. Inflow hydrographs and outflow hydrographs from the sedimentation ponds were developed using the hydrology and sedimentology model SEDIMOT II (Warner et al., 1980; Wilson et al., 1980), or equivalent program. Both of these codes model runoff using the rainfall-runoff function and triangular unit hydrograph of the U.S. Soil Conservation Service (1972).

The design calculations for diversion structures were based on the 10-yr, 6-hr storm event. Similarly, the design calculations for the sedimentation ponds inflow and outflow hydrographs were performed using the 25-yr, 6-hr storm event.

According to the U.S. Soil Conservation Service (1972), the algebraic and hydrologic relations between storm rainfall, soil moisture storage, and runoff can be expressed by the equations,

$$Q = \frac{(P-0.2S)^2}{P+0.8S} \tag{1}$$

and

$$S = \frac{1000}{CN} - 10 \tag{2}$$

where Q = direct runoff volume (inches)
S = watershed storage factor (inches)
P = rainfall depth (inches)
CN = runoff curve number (dimensionless)

It should be noted that (a) Equation (1) is valid only for $P \geq 0.2S$ (otherwise $Q=0$), (b) Equation (2), as stated, is in inches, with the values of 1000 and 10 carrying the dimensions of inches, although metric conversions are possible, and (c) CN is only a convenient transformation of S to establish a scale of 0 to 100 and has no intrinsic meaning.

The average curve number for undisturbed areas was chosen from professional judgement and tabulated values presented in Figure 7-1 using approximate cover densities as reported in R645-301-321. A curve number of 76 was used for the undisturbed areas, assuming a hydrologic soil group of C.

The curve number for disturbed areas was chosen from professional judgment and tabulated values presented by the U.S. Soil Conservation Service (1972). Accordingly, a value of 90 was used for the pad and road areas, and a value of 100 was used for the pond area.

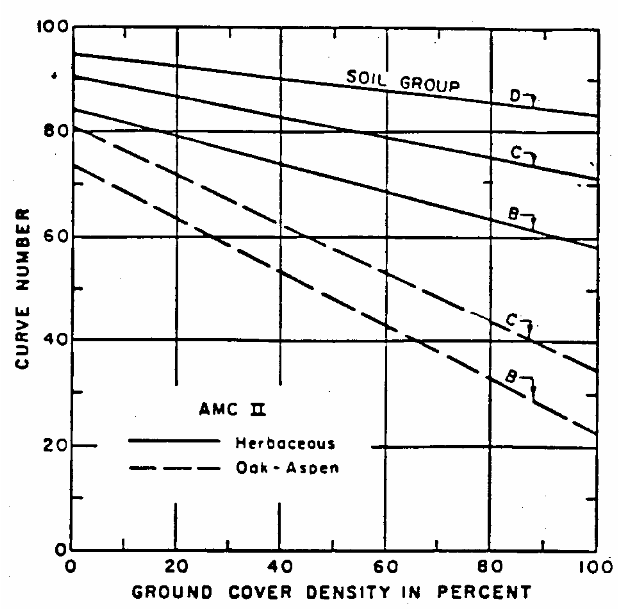
The translation of the runoff depth to an outflow hydrograph is accomplished in the codes using the triangular unit hydrograph of the U.S. Soil Conservation Service (1972). This unit hydrograph is shown in Figure 7-2 along with a typical curvilinear hydrograph. It is characterized by its time to peak (T_p), recession time (T_r), time of base (T_b), and the relations between these parameters (i.e., T_r=1.67T_p; T_b=2.67T_p). Thus, from the geometry of a triangle, the incremental runoff (Q) can be defined by the equation,

$$Q = \frac{(2.67T_p)(q_p)}{2} \qquad (3)$$

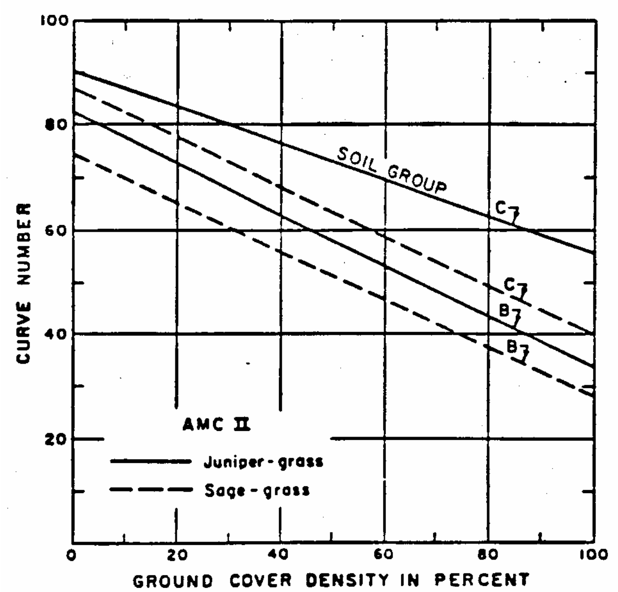
or

$$q_p = \frac{0.75(Q)}{T_p} \qquad (4)$$

where q_p = peak flow rate (dimensioned according to Q and T)



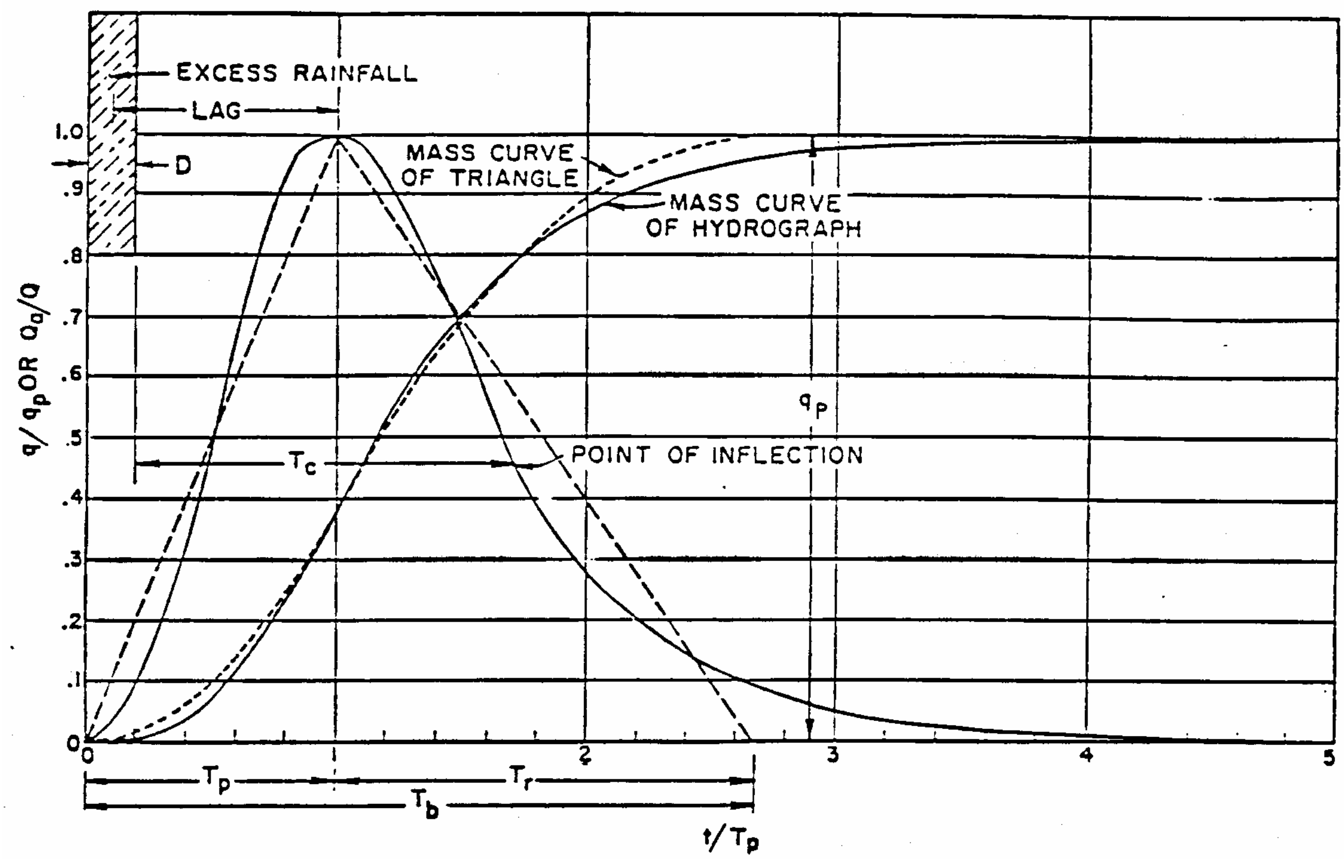
Graph for estimating runoff curve numbers of
forest-range complexes in western United States: herbaceous
and oak-aspen complexes.



Graphs for estimating runoff curve numbers of
forest-range complexes in western United States: Juniper-
grass and sage-grass complexes.

Figure 7-1 Curve Number Graphs

Figure 7-2 Curvilinear and Triangular Unit Hydrographs



When Q is expressed in inches and T_p in hours, q_p will be in inches per hour. The flow at any time $0<t<T_r$ may be determined by simple linear proportioning of the triangular unit hydrograph. The time to peak is related to the familiar expression time of concentration (T_c) by the equation,

$$T_c + t = 1.7T_p \tag{5}$$

in which the factor 1.7 is an empirical finding cited by the U.S. Soil Conservation Service (1972).

The time of concentration may be estimated by several formulas. For this report, T_c was determined from the following equations (U.S. Soil Conservation Service, 1972):

$$L = \frac{l^{0.8}(S+1)^{0.7}}{1900Y^{0.5}} \tag{6}$$

and

$$T_c = 1.67L \tag{7}$$

where L = watershed lag (hours)
l = hydraulic length of the watershed, or distance along the main channel to the watershed divide (feet)
S = watershed storage factor defined in Equation (2-2)
Y = average watershed slope (percent)
T_c = time of concentration (hours)

The precipitation values for the design storm events were obtained from precipitation - frequency maps for the state of Utah prepared by Miller et al., (1973). The precipitation data are presented in Table 7-18.

TABLE 7-18 Precipitation Data for the Co-Op Mine Complex

Frequency (years)	Duration (hours)	Precipitation (inches)
2	6	1.0
10	6	1.5
10	24	2.1
25	6	1.8

Reference: Miller et al., 1973

Sedimentation Ponds

POND CAPACITY

The capacity of each pond is designed based on runoff and sediment storage volumes. The ponds are designed to completely contain the 10-year, 24-hour storm at the required sediment storage capacity. As required by the Utah Division of Oil, Gas & Mining (1990), R645-301-742.221.31 and 742.221.36, adequate sediment control must be provided and maintained by periodic sediment removal.

Runoff Volume. The runoff calculations for those watersheds contributing to each pond were performed as described above. Each analysis was conducted for the 10-year, 24-hour storm event presented in Table 7-18.

Sediment Storage. The annual sediment volumes entering the ponds were calculated using a modified version of the universal soil loss equation (Israelson et al., 1984). The modified universal soil loss equation is:

$$A = R \times K \times LS \times VM \tag{8}$$

where,

A = computed amount of soil loss per unit area for the time interval represented by factor R (tons per acre per year).

R = rainfall factor. R values for Utah presented by Israelson, et al. (1984).

K= soil erodibility factor. K values for Utah presented by Israelson et al. (1984). (tons per acre per year per unit of R).

LS = topographic factor based on length and steepness of slope. (dimensionless).

VM = erosion control factor based on vegetative, chemical, or mechanical measures. (dimensionless).

The maximum sediment storage volume and the 60 pct clean-out level is calculated for each pond.

SPILLWAY ANALYSIS

All sedimentation ponds are constructed with spillways that are designed to pass the peak runoff from the 25-year, 6-hour storm event (DOGM, 1990) presented in Table 7-18. The pond spillways are constructed as a riprapped open channel.

The discharge capacity of the riprapped overflow spillways was determined using a method developed by the U.S. Soil conservation Service (1968) and expanded by Barfield et al. (1981) for broad-crested weirs. According to this methodology, the critical specific energy head (H_{ec}) is determined for selected values of the energy head of water in the pond (H_p) from Figure 7-3. The discharge capacity of the spillway is then calculated for the standard 100-foot wide rectangular section from the equation,

$$q_r = (0.544)(g^{0.5})(H_{ec}^{1.5})(100) \tag{12}$$

where, q_r = discharge for standard 100-foot rectangular section (cubic feet per second)

and all other parameters have been previously defined. The flow is then corrected for a trapezoidal section using the equation,

$$q = [(1.5b + zH_{ec})/150](q_r) \tag{13}$$

where, q = corrected discharge (cubic feet per second)
b = bottom width of channel (feet)
z = channel side slope (run over rise - dimensionless)

Spillway design calculations are performed using the hydrology and sedimentology model SEDIMOT II (Warner et al., 1980; Wilson et al, 1980). It should be noted that the sedimentology option of SEDIMOT II was used during design only to permit routing of the hydrograph through the pond. However, since sediment contributions from the 25-year, 6-hour event are not of concern in design of the pond (only sediment yield from the 10-year, 24-hour and smaller storms is of regulatory concern), the sediment inputs to the model were suppressed.

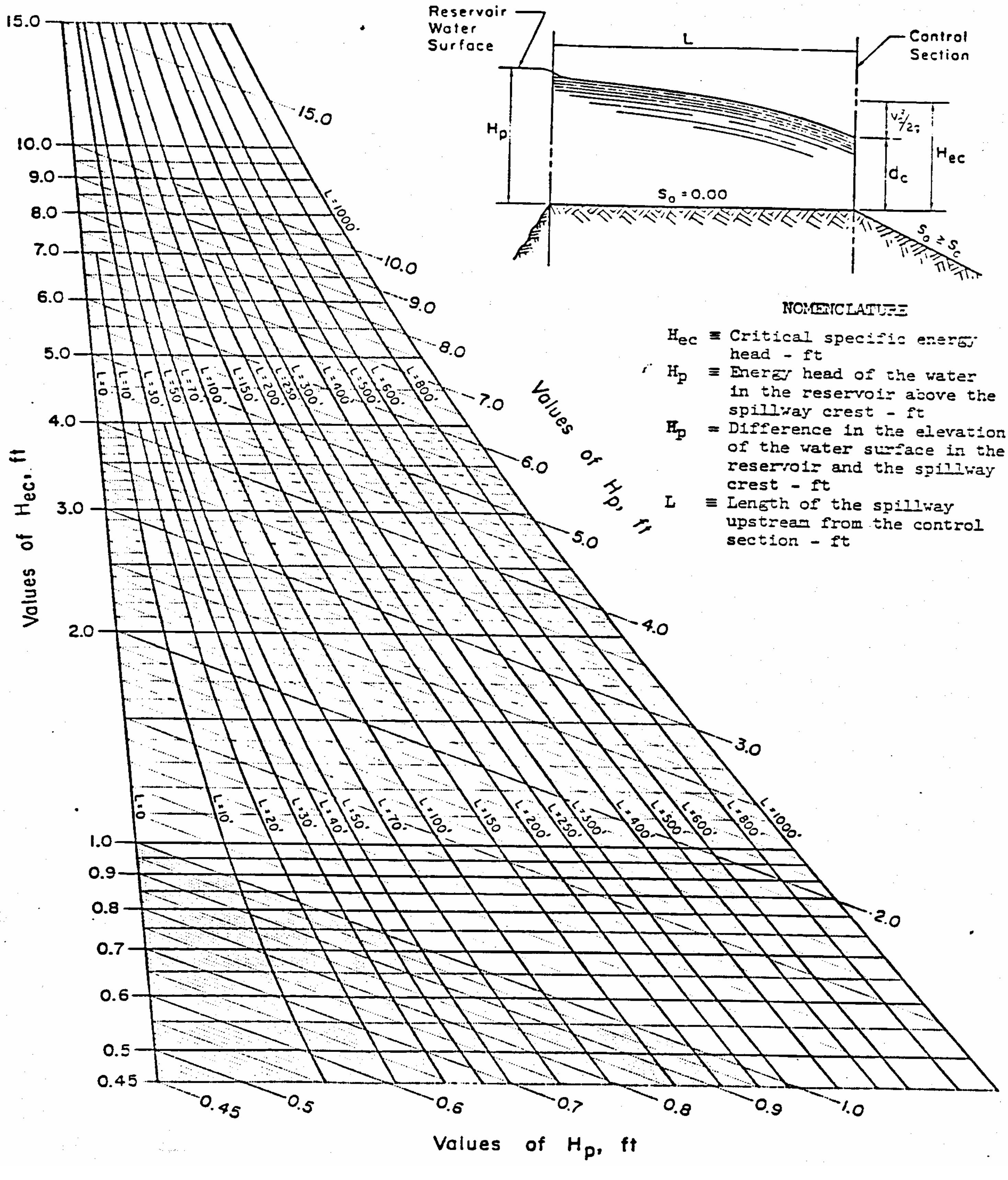


Figure 7-3 Head Relationship for Selected Broad-crest Weirs

Thus, the output from the program indicates sediment concentrations of 0 milligrams per liter. Therefore, sediment yield outputs provided by SEDIMOT II are meaningless.

It should also be noted that, although detention times shown on the SEDIMOT II output are relatively low (less than one hour), these times have no regulatory meaning for a 25-year event (i.e., regulatory concerns address the detention time only for the 10-year and smaller events). Again, the program was used primarily for its spillway design capabilities and not for dealing with the specifics of sediment yield and detention times from the 25-year, 6-hour design event.

The model SEDIMOT II (Warner et al., 1980; Wilson et al., 1980) assumes that the pond is initially full of water to the elevation of the primary spillway when the storm event occurs. This is a conservative assumption since, the pond is typically empty of water to the top of the decant level.

POND CONSTRUCTION AND MAINTENANCE

Pond embankments were constructed in maximum lifts of 18 inches and compacted to 95 pct of T-99 compaction test capabilities at optimum moisture. Dikes are designed to have an 8-foot minimum top width or have a top width not less than (H + 35)/5, whichever is greater. The upstream and downstream slopes were designed not to exceed 1V:1.5H, except in areas where size is restricted. In such cases, steeper slopes were used if a 1.5 safety factor could be demonstrated with the designated soil materials. Where soil moisture was critical to stability, ponds were lined with bentonite clay to prevent seepage. Embankments were keyed into the natural ground surface and unsuitable materials were excluded from the fill. Pond embankments were seeded to reduce erosion, as described in R645-301-331. These methods will provide stability protection from erosion as well as from sudden draw down.

Ponds and basins are regularly inspected and repaired, if necessary. Riprap at major inflow points is replaced if needed. Ponds and basins will be cleaned out when 60% of the design sediment storage capacity has accumulated.

Diversion Structures

BERMS

Earthen berms with a minimum height of 1.5 feet are constructed around the perimeter of all disturbed areas. The location of the berms are presented on Plates 7-1. The berms are used to prevent random discharge from disturbed areas and protect natural drainages or diversions. These berms are routinely maintained.

DRAINAGE DITCHES

The location of diversion ditches are presented on Plates 7-1. The ditches are labeled based on the type of drainage it is diverting (disturbed or undisturbed).

Diversions were designed to convey runoff from a disturbed or undisturbed drainage area. Grades on the diversion ditches are constructed, where possible, at approximately 5 pct. Some critical sections are riprapped with rock to reduce erosion. Ditches are routinely maintained by removing sediment and replacing riprap when necessary.

The ditch capacity and flow velocity was calculated using the Manning and continuity equations (Chow, 1959):

$$V = \frac{1.486}{n} R^{0.67} S^{0.50} \qquad (14)$$

and

$$Q = AV \qquad (15)$$

where, V = velocity (feet per second)
R = hydraulic radius (feet)
S = hydraulic slope (feet per foot)
n = roughness coefficient
Q = discharge (cubic feet per second)
A = flow area (square feet)

Peak discharges for the undisturbed drainage areas were calculated as described above. Values of the roughness coefficient required for the solution of Equation (14) were obtained by comparing local conditions with tabulated values provided by Chow (1959). An average roughness coefficient of 0.035 was representative of most ditches.

The diversion ditch geometries were measured in the field and approximated with trapezoidal or triangular ditch cross sections. The hydraulic slope of each ditch was either measured in the field or approximated from the topographic base maps (scale: 1"=50'). The capacity of each ditch was verified using a minimum slope value in Equation (14) and solving for the depth of flow. The maximum flow velocity for each ditch was calculated using Equation (14) and the maximum ditch slope measured from the topographic base maps. Flow velocities of 5 feet per second or less were considered acceptable for unlined ditches without erosion protection. Where velocities were greater than 5 feet per second, the adequacy of the existing riprap was determined using the methods defined below.

Calculations with Equations (14) and (15) were performed using an interactive computer code entitled FLOWMASTER I as obtained from Haestad Methods, Inc. (1990). This code was used to determine flow conditions in the diversion channel at the design flow rate.

CULVERTS

The location of diversion culverts are presented on Plates 7-1. The culverts are labeled based on the drainage area diverted (disturbed or undisturbed). The location, size, and slope of each culvert were verified in the field.

Peak discharges for the 10-year, 6-hour storm event were calculated as described above. The adequacy of each culvert was determined using nomographs prepared by the U.S. Department of Transportation (1977). These nomographs for circular culverts with inlet control are presented in Figure 7-4. Based on the known culvert size, entrance type, and peak discharge,

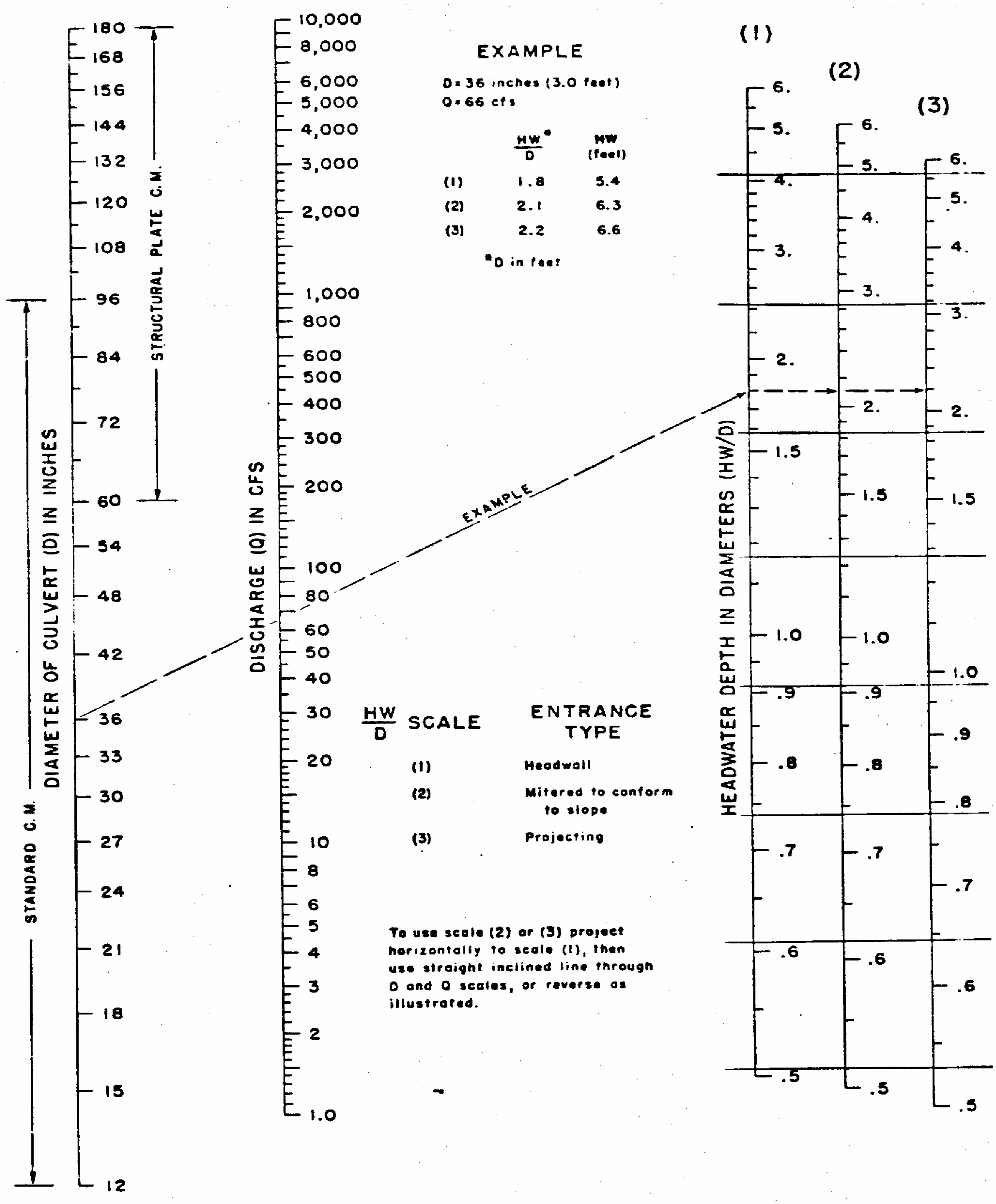


Figure 7-4 Headwater Depths for C.M. Pipe Culverts with Inlet Control

the headwater depth/diameter ratio was determined from the nomograph. If this value was 1.0 or less, the culvert was considered adequate to pass the design discharge rate. If the ratio was greater than 1.0, a closer inspection of the culvert geometry and entrance was necessary.

Exit velocities from each circular culvert were calculated based on equations 14 and 15. Roughness coefficients of 0.024 and 0.011 were used for the calculations, which can be considered typical for corrugated metal pipe and concrete culverts, respectively (Chow, 1959).

Riprap Protection

The use of riprap to line drainage ditches, culvert outlets, channel diversions or spillways is required when flow velocities exceed approximately 5 feet per second. Calculations to determine the adequacy of existing riprap sections are based on a method defined by the U.S. Department of Transportation (1978).

The size of stone needed to protect a diversion channel or spillway from erosion by a current moving parallel to the channel is determined by the use of Figures 7-5 and 7-6. The size of stone (k) is determined by a trial-and-error method which consists of first estimating a stone size.

The mean velocity (V_m) of the water must be converted to the velocity against the stone by the use of Figure 7-5. With the velocity against the stone (V_s), enter Figure 7-5 and read the stone size for the channel side slope (not the hydraulic slope, unless it is steeper than the side slope of the ditch). The stone size from Figure 7-6 is the 50 percent (median) size, by weight, of a well-graded mass of stone with a unit weight of 165 pounds per cubic foot. If the stone size from Figure 7-6 agrees with the assumed stone size, it is correct. If not, the procedure is repeated until agreement is achieved.

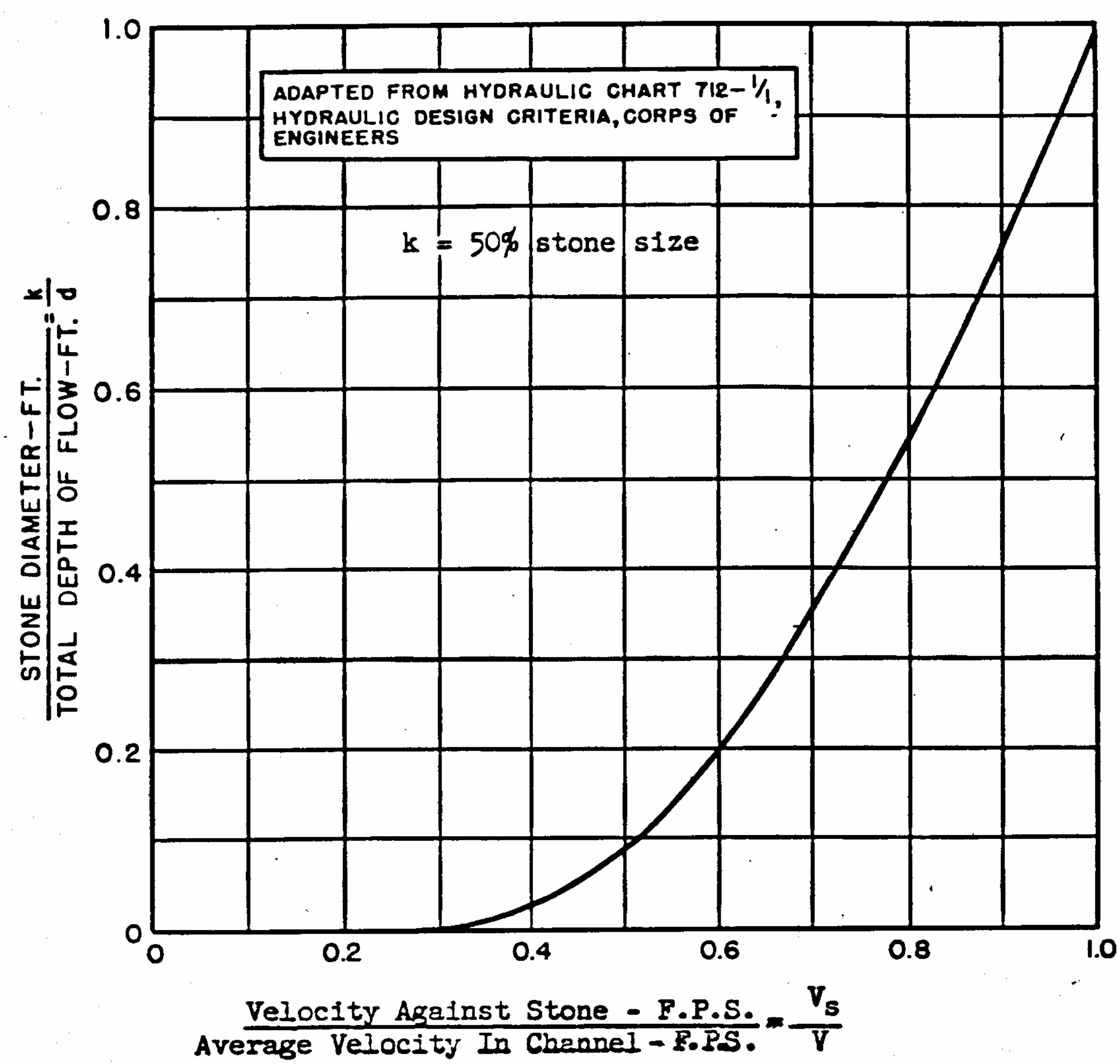


Figure 7-5 Velocity Against Stone on Channel Bottom

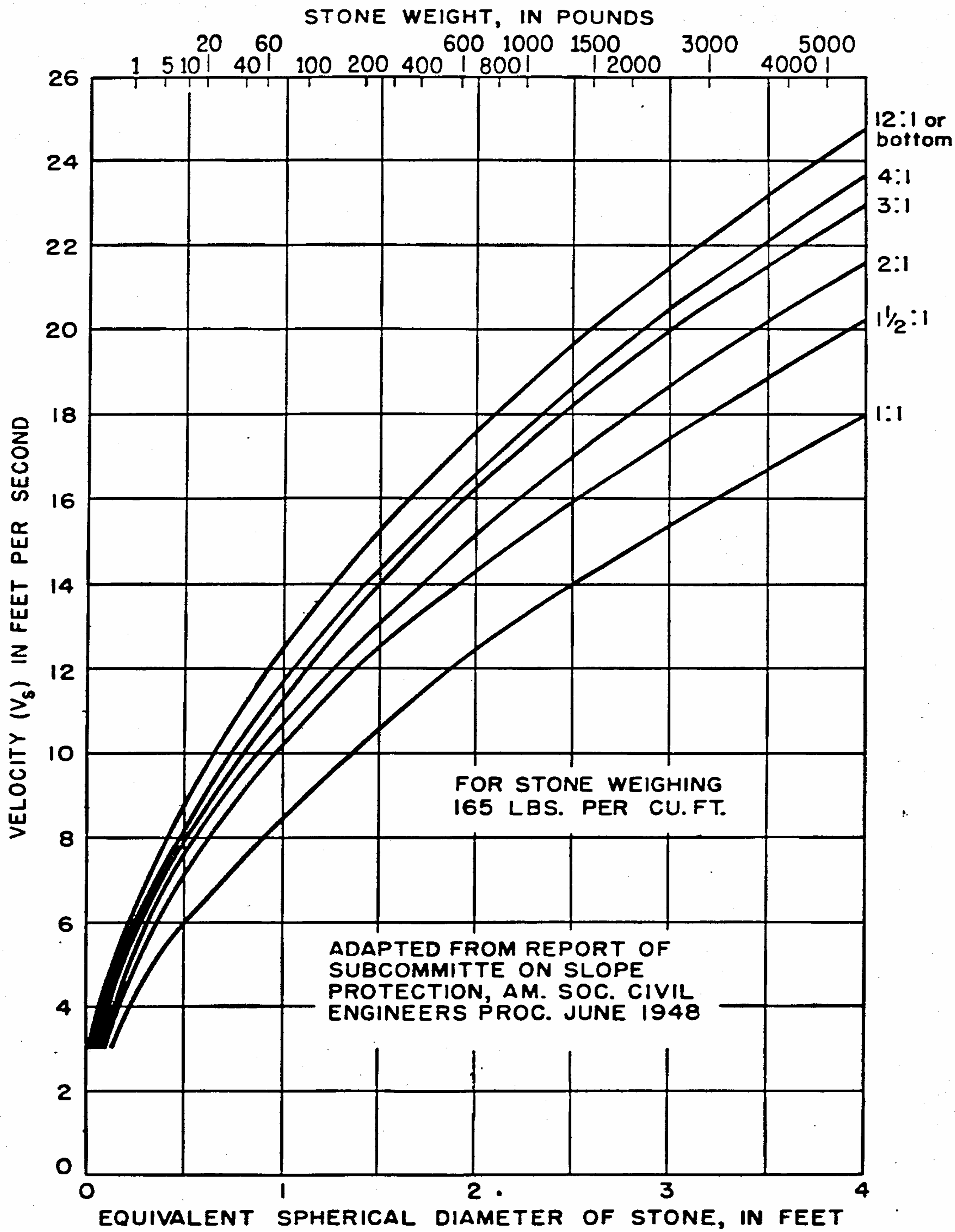


Figure 7-6 Size of Stone that will Resist Displacement for Various Velocities and Side Slopes

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R645-301-742 Sediment Control Measures

742.200 Siltation Structures

In order to reduce potential impacts from sediment, silt fences shall be installed as shown in Figure 7-7. Silt fence locations are noted on Plates 7-1. A more detailed description of sediment control using silt fences can be found in R645-301-742.300 and Appendix 7-K.

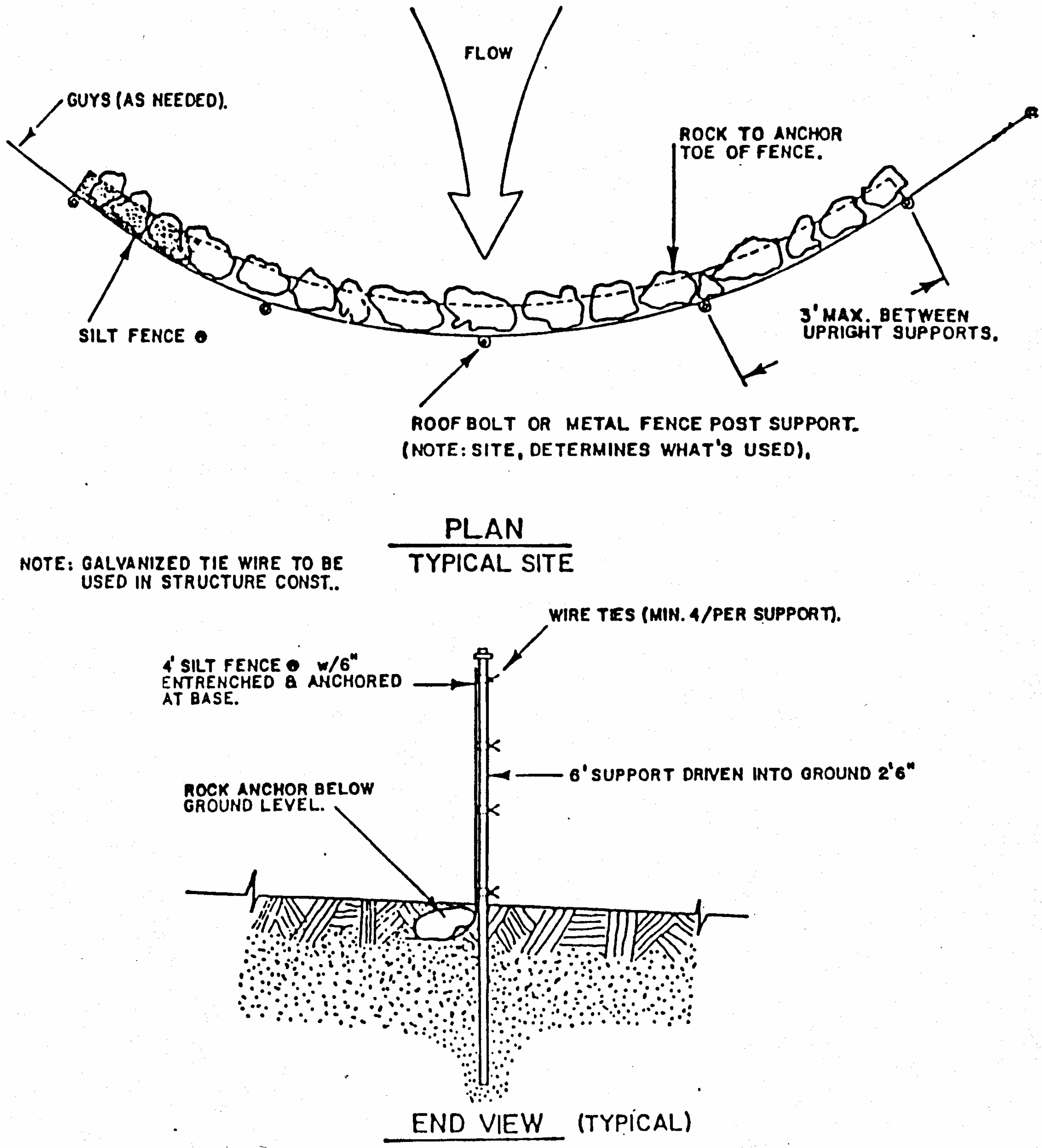


Figure 7-7 Typical Silt Fence

742.220 Sediment Ponds

Four sedimentation ponds, A, B, C, and D have been constructed to hold run-off from the disturbed area of the Mine Plan to facilitate settling and filtering of contaminated surface water from the mine site.

Surveys of A, B, and C sedimentation ponds were conducted in November 1990, and October, 1995, by Olympus Aerial Surveys, Inc. Additional pond surveys were conducted by EarthFax Engineering, Inc. in May, 1991. As-built surveys were completed for ponds A and B in July, 1991, and the topography and cross sections are contained on Plates 7-2 and 7-3, respectively. As-built surveys for Pond C was completed in August, 1993, and the topography and cross-sections are shown on Plate 7-6.

A fourth sediment pond is proposed in 2002 to be built in conjunction with the Bear Canyon No. 3 mine Portal Area. All of the runoff from the portal pad will report to sediment pond D.

Discharge. Discharge from the sediment ponds is to Bear Creek or the Right Fork ephemeral drainage. Each pond is constructed with both an open channel spillway and a decant device, 4 in. valved drainpipe with down turned inlet located above the 60 pct sediment cleanout elevation. The decant device allows for separation of oil, grease and other floatables. Discharge to surface waters is governed by the State of Utah Division of Water Quality. See Appendix 7-B, Discharge Permit.

Sediment Pond A

Calculations were performed on pond A in 1990 to determine whether the existing structure would fully contain the design sediment volume and runoff volume from the 10-yr, 24-hr storm. Also to see if the flow-line of the existing decant device was located at the required elevation of 2-ft above the 60 pct sediment clean out level.

To meet these requirements it was recommended that the pond be deepened 3 to 4 ft. In 1991 the pond was deepened 5 ft or 2 ft deeper than planned to a depth of 7,082 ft. This provides for additional storage and a greater margin of safety.

The stage-capacity curve for pond A is presented in Appendix 7-F. Calculations in Appendix 7-F were updated in Oct 1991 using the as-built dimensions. A summary of the revised data is contained in Table 7-19.

The storm runoff volume from the 10-yr 24-hr storm event is 64,951 cu ft (1.49 acre-ft). The computation of the runoff volume assumed a curve number of 90 for the disturbed areas, 100 for the pond area, and 76 or 83 for the undisturbed drainage contributing to the pond. Assuming the pond fully contains this runoff volume, the decant elevation is 7088 ft. The sediment clean out level is at an elevation of 7086 ft, 2 ft below the decant elevation.

Table 7-19 Sed Pond A Stage-Capacity Data

ELEVATION (FT)	AREA (FT)	INCREMENTAL VOLUME (FT^3)	CUMULATIVE VOLUME (FT^3)
7,082	4826		0
		10,618	
7,084	5,792		10,618
		13,084	
7.086	7,292		23,702
		16,144	
7,088	8,852		39,846
		19,366	
7,090	10,514		59,212
		22,247	
7,092	11,733		81,459
		24,752	
7,094	13,019		106,211
		6,590	
7,094.5 Spillway Flow Line	13,340		112,801
		20,765	
7,096	14,347		133,566
		5,792	
7,096.4 Top of Embankment	14,613		139,336

The maximum sediment storage volume is 39,500 cu ft, located at an elevation of 7087.9 ft. The sediment storage volume at the sediment clean out level elevation of 7086 ft, is 23,702 cu ft. With an estimated annual sediment volume of 3848 cu ft, the enlarged pond will provide over 6 yrs of sediment storage. This scenario will allow for greater sediment storage and less frequent maintenance.

The 25-yr, 6-hr storm was routed through the primary spillway to determine the maximum stage and flow rate. Data obtained from these watersheds were input to a computer code developed by Hawkins and Marshall (1979) to generate runoff hydrographs, which were used for the design of drainage diversions. Inflow hydrographs to and outflow hydrographs from the sedimentation ponds were developed using the hydrology and sedimentology model SEDIMOT II (Warner et al., 1980; Wilson et al., 1980). Both of these codes model runoff using the rainfall-runoff function and triangular unit hydrograph of the U.S. Soil Conservation Service (1972).

Although the max allowable sediment elevation is 7086 ft, computations were conducted assuming that the pond contained the max available sediment volume of 32,288 cu ft at an elevation of 7087.9 ft. It was further assumed that the pond was full of water up to the spillway flow line prior to the start of the design runoff event. This results in a conservative estimation of the max stage since, in general, the pond can be assumed to be empty to the decant elevation at the beginning of a storm event.

From the analysis of the 25-yr, 6-hr storm event, the max inflow rate to the proposed pond structure is 18.65 cu ft per sec (cfs) and the max outflow rate is 13.87 cfs. The corresponding high water elevation is 7095.08, 1.32 ft below the assumed min embankment elevation of 7096.4 ft. Thus, pond A will adequately pass the 25-yr, 6-hr peak flow.

The inlet channel to pond A was evaluated to determine the adequacy of the existing riprap and capacity of the channel during the 25-yr, 6-hr storm event. The calculations for the inlet channel is presented in Appendix 7-F. Based on the min channel slope, the channels has adequate capacity. Based on the max channel slope, the flow velocity is 7.1 ft per sec. Material from the pond has been pushed up to the access road and inlet covering any riprap that may be there. Although this flow velocity is considered erosive, the sediment will be contained by the pond. If erosion is extensive, the inlet will be adequately maintained.

The open channel primary spillway was evaluated to determine the suitability of the existing riprap. Using the peak discharge rate of 13.87 cfs during the 25-yr, 6-hr storm, the flow velocity was calculated to be 7.9 ft per sec. The existing median riprap diameter of 4 in. on the channel bottom and 10 in. on the side slopes is marginally adequate for this flow velocity. The flow velocity and riprap sizing calculations are presented in Appendix 7-F.

Sediment Pond B

Calculations were performed on pond B in 1991 to determine whether the existing structure would fully contain the design sediment volume and the runoff volume from the 10-yr, 24-hr storm. In addition, the flow line of the existing decant device must be located at an elevation of 2-ft above the 60 pct sediment clean out level. As recommended in 1991 the pond was deepened approx 2 to 3 ft to accommodate the criteria discussed above. The following calculations are based on the as-built pond geometry as shown in Plate 7-3.

The stage-capacity data for pond B were determined from the pond topography contained in Plate 7-3. A summary of these data is contained in Table 7-20. The stage-capacity curve for pond B is presented in Appendix 7-F.

The storm runoff volume from the 10-yr 24-hr storm event is 9095 cu ft (0.209 acre-ft). The computation of the runoff volume assumed a curve number of 90 for the disturbed areas, 100 for the pond area, and 76 for the undisturbed drainages contributing to the pond. Assuming the pond fully contains this runoff volume, the decant elevation is 7064.9 ft. The 60 pct sediment clean out level is at an elevation of 7062.9 ft, 2 ft below the decant elevation. The sediment storage volume at the 60 pct clean out level is 2200 cu ft. The maximum sediment storage volume is 3670 cu ft, located at an elevation of 7063.4 ft. With an estimated annual sediment volume of 213 cu ft, the proposed pond design will provide many years of sediment storage. This scenario is proposed since it will allow for greater sediment storage and less frequent maintenance.

Table 7-20 Sediment Pond B

Elevation (Ft)	Area (Ft^2)	Incremental Volume (Ft^3)	Cumulative Volume (Ft^3)
7,062	2,350		0
		2,619.5	
7,063	2,869		2,609.5
		3,142.5	
7,064	3,416		5,752.0
		3,711	
7,065	4,006		9,463.0
		4,260.5	
7,066.9	4,515		13,723.5
		4,276.8	
7,066	4,989		18,000.3
		501.6	
7,067	5,042		18,501.9
		5,310	
7,068	5,578		23,811.9

The 25-year, 6-hour storm was routed through the primary spillway to determine the maximum stage and flow rate. Data obtained from these watersheds were input to a computer code developed by Hawkins and Marshall (1979) to generate runoff hydrographs, which were used for the design of drainage diversions. The inflow hydrograph to and outflow hydrograph from the sedimentation pond was developed using the hydrology and sedimentology model SEDIMOT II (Warner et al., 1980; Wilson et al., 1980). Both of these codes model runoff using the rainfall-runoff function and triangular unit hydrograph of the U.S. Soil Conservation Service (1972).

Computations were conducted assuming that the pond contained the maximum sediment volume of 3670 cu ft. It was further assumed that the pond was full of water up to the spillway flow line prior to the start of the design runoff event. This results in a conservative estimation of the maximum stage since, in general, the pond can be assumed to be empty to the decant elevation at the beginning of a storm event.

From the analysis of the 25-year, 6-hour storm event, the maximum inflow rate to the proposed pond structure is 2.98 cfs and the maximum outflow rate is 2.40 cfs. The corresponding high water elevation is 7067.19, 0.81 ft below the minimum embankment elevation of 7068 ft. Thus, pond B will adequately pass the 25-yr, 6-hr peak flow.

The inlet channels to pond B were evaluated to determine the adequacy of the existing riprap and capacity of the channels during the 25-year, 6-hour storm event. The calculations for the inlet channels are presented in Appendix 7-F. Based on the minimum channel slope, both inlet channels have adequate capacity. The inlet channel adjacent to the road is constructed using grouted riprap and is adequate for the maximum flow velocity of 9.0 ft per second. The flow velocity of 2.2 ft per sec for the northern inlet channel is considered non-erosive and does not require riprap.

The open channel primary spillway was evaluated to determine the suitability of the existing riprap. Using the peak discharge rate of 2.40 cfs during the 25-yr, 6-hr storm, the flow velocity was calculated to be 5.25 ft per sec. The existing median riprap diameter of 6 inches is adequate for this flow velocity. The flow velocity and riprap sizing calculations are presented in Appendix 7-H.

Sediment Pond C

The following calculations are based on the as-built pond geometry shown in Plate 7-6.

The stage-capacity data for pond C are contained in Table 7-21. The stage-capacity curve for pond C is presented in Appendix 7-F.

The storm runoff volume from the 10-yr 24-hr storm event is 7,881 cu ft (0.181 acre-ft). The computation of the runoff volume assumed a curve number of 90 for the disturbed areas, 100 for the pond area. The decant elevation is 7032.3 ft, allowing for a water storage volume of 10,423 cu ft. The 60 pct sediment clean out level is at an elevation of 7030.3 ft, 2 ft below the decant elevation. The sediment storage volume at the 60 pct clean out level is 3,169 cu ft. The maximum sediment storage volume is 5,282 cu ft, located at an elevation of 7031.4 ft. With an estimated annual sediment volume of 126 cu ft, the sediment level would reach the 60 pct cleanout level in approximately 25 years.

Computations were conducted assuming that the pond contained the maximum sediment volume. It was further assumed that the pond was full of water up to the emergency spillway flow line prior to the start of the design runoff event. This results in a conservative estimation of the maximum stage since, in general, the pond can be assumed to be empty to the decant elevation at the beginning of a storm event. Pond C will adequately pass the 25-yr, 6-hr peak flow.

The inlet channel to pond C was evaluated to determine size and riprap requirements. Using the peak discharge rate of 2.66 cfs during the 25-yr, 6-hr storm, the flow velocity was calculated to be 6.03 ft per sec. The channel will be riprapped with 4 in. M.D. riprap. Calculations for the inlet channels are presented in Appendix 7-F.

The open channel primary spillway was evaluated to determine the suitability of the existing rip-rap. Using the peak discharge rate of 2.09 cfs during the 25-yr, 6-hr storm, the flow velocity was calculated to be 4.71 ft per sec. This flow velocity is considered non-erosive and does not require riprap. The depth of flow is 0.09 ft Flow velocity and riprap-sizing calculations are presented in Appendix 7-F.

Table 7-21 Sed Pond C Stage-Capacity Data

ELEVATION (FT)	AREA (FT)	INCREMENTAL VOLUME (FT^3)	CUMULATIVE VOLUME (FT^3)
7,026	22		0
		120	
7,027	218		120
		399	
7,028	579		519
		815	
7,029	1,051		1,334
		1,315	
7,030	1,578		2,648
		1,736	
7,031	1,894		4,384
		2,070	
7,032	2,245		6,454
		2,411	
7,033	2,576		8,864
		2,745	
7,034	2,914		11609
		3,096	
7,035	3,278		14,705
		1,000	
7,035.3	3,390		15,705

Sediment Pond D

This sediment pond is designed to treat the runoff from the No. 3 Mine portal pad in Wild Horse Ridge. The design is based on the proposed geometry shown on Plate 7-11. The stage-capacity data for pond D is shown in Table 7-22. A stage-capacity curve is presented in Appendix 7-F, along with the design calculations.

The storm runoff volume from the 10-yr 24-hr storm event is 3,855 cu ft (0.088 acre-ft). The computation of the runoff volume assumed a curve number of 90 for the disturbed area and the pond area. The decant elevation is 7648 ft, allowing for a water storage volume of 5,565 cu ft. The 60 pct sediment clean out level is at an elevation of 7646.3 ft, 1.7 ft below the decant elevation. The sediment storage volume at the 60 pct clean out level is 665 cu ft. The maximum sediment storage volume is 1,109 cu ft, located at an elevation of 7647 ft. With an estimated annual sediment volume of 24 cu ft, the sediment level would reach the 60 pct cleanout level in approximately 27 years.

The spillway calculations were made assuming that the pond contained the maximum sediment volume and was full of water up to the emergency spillway flow line prior to the start of the design runoff event, and assuming all of the flow went through the emergency spillway. This results in a conservative estimation of the maximum stage and spillway design since the pond could be assumed to be empty to the decant elevation at the beginning of the storm event. The outlet structures will, therefore, adequately pass the 25-yr, 6-hr peak flow.

The inlet channel to pond D was evaluated to determine size and riprap requirements. Using a peak flow of 1.03 cfs for the 10-yr, 24-hr sorm, the flow velocity was calculated to be 6.62 fps. The channel will be riprapped with 4 in. M.D. riprap. The inlet design calculations are shown in Appendix 7-F.

For the emergency spillway, the flow velocity was determined to be 8.04 fps. To prevent erosion, the spillway will be riprapped with 6" M.D. riprap. The spillway design calculations are also shown in Appendix 7-F. A minimum safety factor of 1.36 was determined for rapid drawdown conditions.

Table 7-22 Sediment Pond D Stage-Capacity Data

Elevation (ft)	Area (ft^2)	Incremental Volume (ft^3)	Cumulative Volume (ft^3)
7,644	42.2		0
		125	
7,645	208.65		125
		338	
7,646	467.98		463
		646	
7,647	825.02		1,109
		1,050	
7,648	1,274.70		2,159
		1,619	
7,649	1,962.65		3,778
		2,417	
7,650	2,871.97		6,195
		1,529	
7,650.5	3,243.73		7,724

Slope Stability Analysis

A computer slope stability analysis for pond "A" is contained in Appendix 7-E. The computer analysis of the sediment pond included the condition under which the most conservative factor of safety would be derived. This is a condition wherein the soil is saturated from the sediment pond being full of water and then the analysis is run with the sediment pond empty. For purposes of analysis the soil was assumed saturated by the water occasionally held in the pond. The cross-sections towards the back of Appendix-E indicate a division between soil No. 2 and soil No. 1. Referring back to the computer printout sheets, soil No. 2 is indicated to be in a saturated condition.

Again, this analysis provides for the most conservative results and is the worst condition; which would only occur after saturation due to the sediment pond being full and then after rapid "draw-down" or dewatering of the sediment pond. This same material was used in the construction of Ponds “B” and “C”. A Slope Stability Analysis of the material to be used to construct Sediment Pond “D” is shown in Appendix 5-J.

Pond Maintenance and Monitoring

All embankments of temporary impoundments, surrounding areas, and diversion ditches, disturbed or created by construction shall be graded, fertilized, seeded and mulched to comply with the requirements of R645-302-353 immediately after the embankment is

complete. Areas in which the vegetation is not successful, or where rills and gullies develop shall be repaired and revegetated.

In addition, all dams and embankments shall be routinely maintained during the mining operation. Any vegetative growth will be cut where necessary to facilitate inspection and repairs. Ditches and spillways shall be cleaned as needed. Any combustible materials present on the surface shall be removed and all other appropriate maintenance procedures followed.

Sediment ponds will be cleaned out when they reach the 60 pct clean out level. Sediment material from the sedimentation ponds will be placed in the sediment pond waste area (Plate 5-2C) and is discussed in Appendix 5-O.

Quarterly Inspections. Quarterly inspections will be made of all sediment ponds and submitted to DOGM with the quarterly Water Monitoring Report. If any inspection discloses that a potential hazard exists, Co-Op will notify the Division immediately as required by R645-301-515.200.

Annual Inspections. Annual inspections will be made by a qualified registered professional engineer of all sediment ponds and a certified report will be submitted to the Division with the annual report. The report will include discussion of items noted in R645-301-514.312. Copies of the reports will be placed in Appendix 7-I.

Portal Pad Catch Basin

Runoff from the Belt Portal Pad area is collected and totally contained in a catch basin at the base of the road slope (See Plates 5-2 and 5-5). Calculation factors for catch basin sizing are listed below.

Factor	Value
Area	3,765 ft^2
Soil Type	C
Min Infiltration Rate	0.05 to 0.15 in./hr use 0.10 in./hr, see p 7F-7
6 hr-10 yr Storm	1.38 in. (0.23 in./hr)
Rainfall Data Base	Hiawatha Data by E. Arlo Richardson. See App 7-G.

Total Accumulation 245 ft^3

(3,765 ft^2 x (0.23 in./hr - 0.10 in./hr) x 1 ft/12 in. x 6 hr

Catch Basin Size	442 ft^3
Area	354 ft^2
Av Depth	1.25 ft
Berm Height	1.5 ft min
Excess Volume	198 ft^3

Note: The hoist located in the basin is a tubular structure and will not appreciably affect the overall storage capacity of the catch basin and will not jeopardize the structure's effectiveness during the design event.

742.300 Diversions

The majority of the disturbed area of the Bear Canyon Mine is on the west side of Bear Canyon (same side as the No. 1 and 2 mine portals and to the south). Run-off from this west side disturbed area is collected and channeled to Sedimentation Ponds "A" and “C” with exception of runoff from the ASCA areas (Alternate Sediment Control Areas) which are described in Appendix 7-K. The small amount of run-off from the disturbed area east of Bear Creek where the scale house building is located is channeled to Sedimentation Pond "B”. The runoff from the Wild Horse Ridge Portal Area is channeled to Sediment Pond “D”. Remaining disturbed areas are designated as ASCA’s and treated as described in Appendix 7-K. In order to minimize the amount of water crossing the disturbed area, run-off from the undisturbed areas above are diverted around or channeled through the disturbed areas and into Bear Creek. Plates 7-1 show the arrangement of the various sedimentation and diversion structures.

The existing facilities within the Co-Op Mine were constructed in a manner, which minimizes changes to the prevailing hydrologic balance. Contributions of sediment to the stream channel are prevented by diverting drainage from undisturbed areas away from the site. In addition, existing sedimentation ponds collect disturbed area surface runoff, and a system of berms around the disturbed areas prevent drainage to the stream channel.

In addition, Co-Op implemented an extensive interim revegetation program in October 1983 wherein soil tackifiers and mulches were utilized to stabilize the soil for vegetation establishment. Additional interim revegetation has been performed since that time as required.

Storm Runoff Calculations

Peak discharge rates from the undisturbed and disturbed area drainages of the Co-Op Mine were calculated for use in determining the adequacy of the existing diversion ditches and culverts. The storm runoff calculations for the temporary diversion structures were based on the 10-year, 6-hour storm event of 1.5 inches of precipitation (Miller et. al., 1973).

The undisturbed drainage areas for the Co-Op Mine are presented on Plate 7-5. The disturbed drainage areas are presented on Plates 7-5 and 7-1. Each drainage area is labeled according to whether it contributes to the pond (typically, disturbed) or is diverted (undisturbed). For example, AU-6 represents undisturbed watershed number 6.

Curve numbers for the undisturbed drainage areas were estimated from vegetation data presented in R645-301-321, and by field observations. Cover densities were estimated from information presented in R645-301-321. Based on a cover density of 40 pct, a curve number of 76 for the undisturbed areas was estimated using Figure 7-1. Curve number calculations are presented in Appendix 7-G.

The curve number for disturbed areas was chosen from professional judgment and tabulated values presented by the U.S. Soil Conservation Service (1972). Accordingly, a value of 90 was used for the pad and road areas.

Data obtained from the watersheds were input to a computer code called "Peak" to generate runoff hydrographs. This computer code models runoff using the rainfall-runoff function and triangular unit hydrograph of the U.S. Soil Conservation Service (1972). A summary of the runoff calculations is presented in Table 7-23. All runoff calculations are contained in Appendix 7-G.

Diversion Structures

Diversion structures within the Co-Op Mine area include drainage ditches and culverts to convey storm runoff from disturbed and undisturbed drainage areas, and berms to contain disturbed-area drainage. These diversion structures are located on Plates 7-1. The peak discharge rates are based on the 10-year, 6-hour storm event.

The dimensions of the existing diversion ditches and berms were measured in the field. The measurements approximate either a trapezoidal or triangular shape. Typical sections for each diversion identified on Plates 7-1 are contained in Table 7-24 in tabular form.

The capacity of existing diversion ditches was determined by calculating the normal depth of flow based on a minimum ditch slope. The maximum flow velocity was calculated based on the maximum ditch slope. Ditch slopes were measured in the field and estimated from topographic maps with a scale of 1" = 50'. An average ditch slope was measured for those sections without an apparent change in grade. Maximum and minimum slopes were measured where applicable. A summary of ditch calculations is presented in Table 7-24. All ditch calculations are contained in Appendix 7-G.

Table 7-23 Summary of Storm Runoff Calculations for 10 Year 6 Hour Storm

Watershed	Curve Number CN	Time of Concentration (Hr)	Drainage Area (Acres)	Peak Discharge (CFS)
AU-1	76	0.094	6.46	0.83
AU-1A	83	0.032	1.36	0.51
AU-1B	83	0.026	1.16	0.44
AU-1C	76	0.120	16.40	1.95
AU-2	76	0.075	2.23	0.30
AU-2A	76	0.077	1.64	0.22
AU-2B	76	0.081	3.80	0.51
AU-3	76	0.078	3.87	0.52
AU-3A	76	0.016	0.30	0.05
AU-4	76	0.093	7.97	1.02
AU-4A	83	0.029	0.92	0.35
AU-5	76	0.104	20.14	2.51
AU-6	76	0.059	2.73	0.39
AU-7	76	0.094	13.46	1.72
AU-8	76	0.050	4.95	0.72
AU-9	76	0.100	4.77	0.60
AU-10	76	0.137	35.52	4.05
AU-11	76	0.045	0.62	0.09
AU-12	76	0.050	2.33	0.34
AU-13	76	0.022	0.66	0.10
AU-14	76	0.050	2.43	0.35
AU-15	76	0.058	0.91	0.13
AU-16	76	0.152	44.93	4.92
AU-17	76	0.152	30.10	3.29
AU-18	76	0.152	36.55	4.00
AU-19	76	0.144	36.03	4.03

Table 7-23 Summary of Storm Runoff Calculations for 10 Year 6 Hour Storm (cont)

Watershed	Curve Number CN	Time of Concentration (Hr)	Drainage Area (Acres)	Peak Discharge (CFS)
AU-20	76	0.131	20.55	2.37
AU-21	76	0.110	9.45	1.15
AU-22	76	0.086	12.12	1.59
AU-23	76	0.093	5.25	0.64
AU-23A	76	0.033	0.28	0.04
AU-24	76	0.119	13.89	1.66
AU-25	76	0.087	2.27	0.30
AU-26	76	0.033	0.63	0.10
AU-27	76	0.027	0.2	0.03
AU-28	76	0.039	0.59	0.09
AU-28A	76	0.071	0.99	0.14
AU-29	76	0.025	1.29	0.29
AU-29A	76	0.023	0.55	0.67
AU-30	76	0.029	0.49	0.08
AU-31	76	0.048	2.21	0.32
AU-32	76	0.036	1.84	0.28
AU-33	76	0.040	0.71	0.11
AU-34	76	0.045	1.84	0.27
AU-35	76	0.032	0.2	0.13
AU-36	76	0.031	0.75	0.12
AU-37	76	0.198	139.82	13.64
AU-38	76	0.094	8.97	1.15
AU-39	76	0.048	1.26	0.18
AU-40	76	0.283	197.5	15.96
AU-41	76	0.100	11.59	1.46
AU-42	76	0.002	4.24	0.67
AU-43	76	0.095	13.7	1.75

Table 7-23 Summary of Storm Runoff Calculations for 10 Year 6 Hour Storm (cont)

Watershed	Curve Number CN	Time of Concentration (Hr)	Drainage Area (Acres)	Peak Discharge (CFS)
Bear Creek	76	0.604	1,728	108.18
Bear Creek[1]	76	0.604	1,728	108.18

Table 7-23 Summary of Storm Runoff Calculations for 10 Year 6 Hour Storm (cont)

Watershed	Curve Number CN	Time of Concentration (Hr)	Drainage Area (Acres)	Peak Discharge (CFS)
AD-1A	76	0.090	3.70	0.48
AD-1B	76	0.037	2.12	0.32
AD-2A	76	0.040	0.97	0.15
AD-2B	83	0.025	1.08	0.41
AD-2C	83	0.012	0.25	0.10
AD-3A	76	0.034	1.49	0.23
AD-3B	76	0.034	0.78	0.12
AD-4	83	0.011	0.08	0.03
AD-5	76	0.056	2.13	0.30
AD-6	90	0.220	1.39	0.81
AD-7	90	0.145	2.95	1.83
AD-8 upper	90	0.021	0.70	0.48
AD-8 lower	90	0.247	2.79	1.59
AD-9	90	0.069	0.35	0.23
AD-10 upper	90	0.026	0.30	0.20
AD-10 lower	90	0.078	0.65	0.42
AD-11	95	0.011	0.69	0.65
AD-12 upper	90	0.020	0.22	0.15
AD-12 lower	90	0.076	0.34	0.22
AD-13	91	0.106	1.78	1.23
AD-14	90	0.009	0.08	0.05
AD-15	90	0.069	1.83	1.20
AD-16	90	0.030	0.77	1.24
AD-17	90	0.019	0.24	0.16
AD-18	90	0.170	0.9	0.55
AD-19	90	0.009	0.15	0.10
AD-20	90	0.019	0.47	0.32

[1] Sized for the 100 Yr – 6 hr storm event.

Table 7-24 Summary of Division Ditch Calculations

Ditch	Bottom Width (Ft)	Top Width (Ft)	Depth (Ft)	Type Side Slope H:V	Measured Slope %	Contributing Watershed	REQ'D Av. Rip-Rap Size (In.)
D-1D	0	1.33	0.67	1:1	2 Min 11 Max	AD-3A	Soil
D-2D	0	1.33	0.67	1:1	6 Min 20 Max	AD-3A, AD-5	Bedrock
D-3D	0	2	1	1:1	2 Min 6 Av. 18 Max	AD-3A, AD-5, AD-7	Soil Soil Grouted
D-4D	0	2	1	1:1	2 Min 6 Av. 17 Max	AD-14	Soil Soil D_{50} 6"
D-5D	0	1.33	0.67	1:1	4 Min 10 Max	AD-9	Soil
D-6D	0	3	1.5	1:1	2 Min 4 Max	AD-3A, AD-5 AD-7, AD-9, AD-10 AD-12, AD-14	Soil
D-7D	2	3.5	0.75	1.5:1	2 Min 6 Av. 55 Max	AD-1A, AD-1B, AD-2A AD-2B, AD-2C, AD-3B AD-4, AD-6, AD-8	Soil Soil D_{50} 6"
D-8D	0	2	1	1:1	2 Min 7 Max	AD-13	Soil
D-8D Water Bar	0	14	0.33	6:1	3 Av.	AD-13	Soil
D-9D	0	2	1	1:1	4 Min 10	AD-15	Soil
D-10D	1	3.33	0.67	1.5:1	7 Min 50	AD-6, AD-3B, (part) AD-2B, AD-2C	D_{50} 4" Bedrock
D-11D	0	1	0.5	1:1	41 Min Near Vert.	Tipple Wash Hose	Grouted Rip-Rap
D-12D	0	1	0.5	1:1	81 Av.	Tipple Wash Hose	Soil
D-13D Water Shed	0	6	0.5	10:1 2:1	0.5 Av.	AD-6 Partial	Soil
D-14D	0	1.33	0.67	1.5:1	0.06 Av.	AU-4A	Soil
D-15D	0	2.00	1.00	1:1	0.05 Av.	AD-16	Soil
D-16D	0	1.50	1.75	1:1	0.05 Av.	AD-18	Soil
D-17D	0	.96	1	1:1	0.08 Av.	AU-23, AD-20	Soil

Notes: 1. Dimensions given indicate minimum requirements. Actual dimensions may vary. Minimum required cross-sections will be maintained.

2. The use of line drainage ditches is required when flow velocities exceed approximately 5 feet per second. Rip-rap may be installed where not required.

Table 7-24 Summary of Division Ditch Calculations (Cont)

Ditch	Bottom Width (Ft)	Top Width (Ft)	Depth (Ft)	Type Side Slope H:V	Measured Slope %	Contributing Watershed	REQ'D Av. Rip-Rap Size (In.)
D-1U	2	1.33	0.67	1:1	2 Min 8 Max	AU-5	Soil
D-2U	0	1.33	0.67	1:1	7 Min 10 Max	AU-6, AU-11	Soil
D-3U	1	2	0.5	1:1	4 Min 18 Max	AU-8	Soil
D-4U	1	4	1	1.5:1	1 Min 10 Av. 18 Max	AU-10	Soil Soil D_{50} 6"
D-5U	0	1	0.5	1:1	4 Min 13 Max	AU-15	Soil
D-6U	0	1.33	0.67	1:1	3 Min 16 Max	AU-14	Soil
D-7U	0	1.33	0.67	1:1	1 Min 16 Max	AU-12	Soil
D-8U	2	4	0.67	1:1	2 Min 31 Max	AU-1, AU-1[a], AU-1B, AU—1C, AU-2, AU-2[a], AU-2B	Soil
D-9U	3	5	1	1:1	1 Min 6 Max	AU-16	Soil D_{50} 4"
D-10U	3	4	0.5	1:1	3 Min 10 Max	AU-17	Soil
D-11U	0	2	1	1:1	3 Min 8 Max	Misc. road damage	Soil
D-12U	0	3	1	1.5:1	3 Min 9 Max	AU-18	Soil D_{50} 4"
D-13U	0	2	1	1:1	2 Min 23 Max	Misc. road damage	Soil
D-14U	4	5.5	0.5	1.5:1	6 Min 66 Max	Sed Pond A Outlet	D_{50} 4" D_{50} 10"
D-15U	0	2	0.67	1.5:1	5 Min 16 Max	AU-3	Soil
D-16U	0	2	0.67	1.5:1	10 Av.	AU-1B	Soil

Table 7-24 Summary of Division Ditch Calculations (Cont)

Ditch	Bottom Width (Ft)	Top Width (Ft)	Depth (Ft)	Type Side Slope H:V	Measured Slope %	Contributing Watershed	REQ'D Av. Rip-Rap Size (In.)
D-17U	0	2	0.67	1.5:1	13 Av.	AU-1[a]	Bedrock
D-18U	0	2	0.67	1.5:1	5 Min	AU-1	Soil
D-19U	0	2	0.67	1.5:1	6 Av.	AU-2B	Soil
D-20U	0	1.33	0.67	1:1	16 Av.	AU-42	Soil
D-21U	0	2	1.0	1:1	13 Av.	AU-43	D_{50}=3"
D-22U	0	3	1.0	1.5:1	11 Av.	AU-19, AU-25	D_{50}=6"
D-23U	0	1.16	0.58	1:1	19 Av.	AU-36	Soil
D-24U	0	1.16	0.58	1:1	14 Av.	AU-35	Soil
D-25U	0	1	0.5	1:1	16 Av.	AD-17	Soil
D-26U	0	1	0.5	1:1	24 Av.	AU-32	Soil
D-27U	0.50	2	0.5	1.5:1	13 Min, 30 Max	AU-31	Soil
D-28U	0	1	0.5	1:1	14 Av.	AU-33	Soil
D-29U	0	1.33	0.67	1:1	8 Av.	AU-34	Soil
D-30U	0	1.16	0.58	1:1	13 Av.	AU-25	Soil
D-31U	0	3	1.0	1.5:1	12 Av.	AU-20, AU-26	Bedrock
D-32U	0	1	0.5	1:1	17 Av.	AU-30	Soil
D-33U	0	1.16	0.58	1:1	18 Av.	AU-29	Soil
D-34U	1	2.74	0.58	1.5:1	11 Av.	AU-24	Soil
D-35U	0	2.0	1.0	1:1	10 Av.	AU-29	Soil
D-36U	0	1.0	0.5	1:1	8 Av.	AU-27	Soil
D-37U	0	1.4	0.7	1:1	8 Av.	AU-26, AU-21	Soil
D-38U	0	1.33	.0.67	1:1	12 Min, 20 Max	AU-21	D_{50}=3"
D-39U	0	1.0	0.5	1:1	10 Av.	AU-28	Soil

Table 7-24 Summary of Division Ditch Calculations (Cont)

Ditch	Bottom Width (Ft)	Top Width (Ft)	Depth (Ft)	Type Side Slope H:V	Measured Slope %	Contributing Watershed	REQ'D Av. Rip-Rap Size (In.)
D-40U	0	1.5	0.75	1:1	9 Av.	AU-24A, C-39U	D_{50}=3
D-41U	0	2	1	1:1	15 Av.	AU-22, AU-23A, C-40U	D_{50}=4
D-42U	0	0.5	0.25	1:1	36 Min, 63Max	AU-23A	Soil
D-43U	0	2	2	2:1	20 Min, 45 Max	AU-23	D_{50}=5

Notes:

1. Dimensions given indicate minimum requirements. Actual dimensions may vary. Minimum required cross-sections will be maintained.
2. The use of riprap to line drainage ditches is required when flow velocities exceed approximately 5 feet per second. Riprap may be installed where not required.

All calculations for the diversion ditches resulted in a maximum flow velocity of less than the maximum permissible velocity. A flow velocity of less than 5 feet per second was considered non-erosive for those ditch sections with little or no riprap or vegetation. For those ditch sections with an abundance of vegetation or riprap maximum permissible velocities were based on the channel characteristics as presented in Appendix 7-G.

Fifty-three culverts have been or will be installed within the Co-Op Mine area to divert storm runoff from the disturbed and undisturbed drainage areas. These culverts were located in the field and are identified on Plates 7-1.

The adequacy of the culverts to pass the design flow rate was determined. Table 7-25 summarizes the culvert sizing calculations. Because the resulting HW/D (headwater depth divided by the culvert diameter) ratio is less than one for each culvert, these existing culverts will adequately pass the design storm. Culvert calculations are presented in Appendix 7-G.

The slope of each culvert was measured in the field. Calculations were performed to determine the exit velocities at each culvert and the required riprap. A summary of the culvert flow velocity and riprap sizing calculations is presented in Table 7-25. Culvert flow velocity computations are presented in Appendix 7-G.

Where culvert exit velocities were in excess of the maximum permissible velocity, erosion protection measures were designed. These measures are presented in Appendix 7-G.

Table 7-25 Culvert Characteristics

Culvert	Diameter (in.)	Type	Contributing Watersheds	Slope (ft/ft)	Outlet Condition
C-21U	36	CMP	Right Fork Drainage	0.06	Bedrock
C-22U	20	CMP	AU-19, AU-25	0.06	Soil
C-23U	36	CMP	AU-36, AU-35, AU-34, AU-20, AU-26, C-24U	0.06	11” rip-rap
C-24U	32	CMP	AU-40, C-25U	0.06	10” rip-rap
C-25U	30	CMP	AD-17, C-26U	0.06	8” rip-rap
C-26U	30	CMP	AU-39, AU-32, AU-33, C-30U, C-34U	0.06	8” rip-rap
C-27U	15	CMP	AU-22, AU-28, AU29A, AU-31	0.06	4” rip-rap
C-28U	15	CMP	AU-43, C-29U	0.06	4” rip-rap
C-29U	15	CMP	AU-20, AU-25, AU-26	0.06	3” rip-rap
C-30U	15	CMP	AU-21, AU-27, AU-30	0.06	Soil
C-31U	12	CMP	AU-29	0.06	Soil
C-32U	15	CMP	AU-22, AU-28, AU-29A	0.06	3” rip-rap
C-33U	24	CMP	AU-24, AU-28A, AU-37	0.06	8” rip-rap
C-34U	24	CMP	AD-19, AU-31, AU-37, AU-38, C-31U, C-32U	0.06	8” rip-rap
C-35U	84	CMP	Bear Creek	0.06	48” rip-rap
C-36U	15	CMP	AU-27, AU-21	0.11	3” rip-rap
C-37U	15	CMP	Abandoned In Place		
C-38U	15	CMP	AU-28	0.08	Soil
C-39U	15	CMP	AU-22, AU-32A, C-40U	0.18	6” rip-rap
C-40U	12	CMP	AU-23	0.001	Soil

Table 7-25 Culvert Characteristics (Cont)

Culvert	Diameter (in.)	Type	Contributing Watersheds	Slope (ft/ft)	Outlet Condition
C-1D	15	CMP flexible	AD-6, AD-3B	1.00	24" rip-rap
C-2D	15	CMP, RCP flexible	AD-2B, AD-2C, AD-3B, AD-4, AD-6	4.0	10" rip-rap
C-3D	20	slt pipe	AD-3A	0.03	4" rip-rap
C-4D	21	CMP	AD-3A, AD-5, AD-7, AD-14, C-10D	0.18	9" rip-rap
C-5D	18	CMP	AD-9	0.08	Soil
C-6D	12	CMP	AD-10	0.48	9" rip-rap
C-7D	18	CMP	Abandoned In Place		
C-8D	18	CMP	AD-3A, AD-5, AD-7	0.05	3" rip-rap
C-9D	18	CMP	See C-8D	0.05	3" rip-rap
C-10D	18	CMP	Tipple Wash Hose	0.03	Soil
C-11D	12	CMP flexible	AD-4A	0.05 0.25	3" rip-rap
C-12D	8	CMP	AD-18	0.05	Soil
C-13D	12	CMP	AU-23, AD-20	0.07	Soil

Diversion Structures Modifications

Culvert C-8U Extension, 1989

In order to reduce migration of coal fines into undisturbed drainage, culvert C-8U which passes under the storage pad, was extended uphill approximately 60 ft during the summer of 1989. A berm will be built to meet the required headwater and to prevent runoff to the south from entering the drainage. The headwall will be riprapped and the existing trash rack will be resecured to the culvert as presently installed. Extending the culvert will increase the distance between the coal storage and the inlet to the culvert.

A small sediment basin will be constructed and maintained at the inlet of culvert C-8U in the Spring of 1992, and cleaned as needed to reduce potential impacts of suspended solids to surface waters.

Culvert Outlet C-1U 1991

In order to reduce erosion occurring at the outlet of culvert C-1U, a flexible culvert was added to the end of the in-place culvert. The extension extends to a point where the discharge is onto the rock cliff. The only runoff that crosses the slope below the Upper Storage Pad will then be the direct impact precipitation. The flexible culvert is attached to the slope using the method identified in Figure 7-13. Vegetation will be evaluated, stabilized, and supplemented as required.

A splash basin and drainage channel will be established at the immediate impact area in the downcast material at the base of the cliff, to direct drainage to the original drainage path. Due to the inaccessible nature of the location all work will be performed by hand. This limits the size of rip-rap that can be placed so the construction will be reviewed by qualified personnel along with the division. See Figure 7-8 for a profile of the cliff and downfall area. The remaining downcast material in the pile at the base of the cliff will be stabilized with erosion control matting and using interim reclamation procedures defined in R545-301-331.

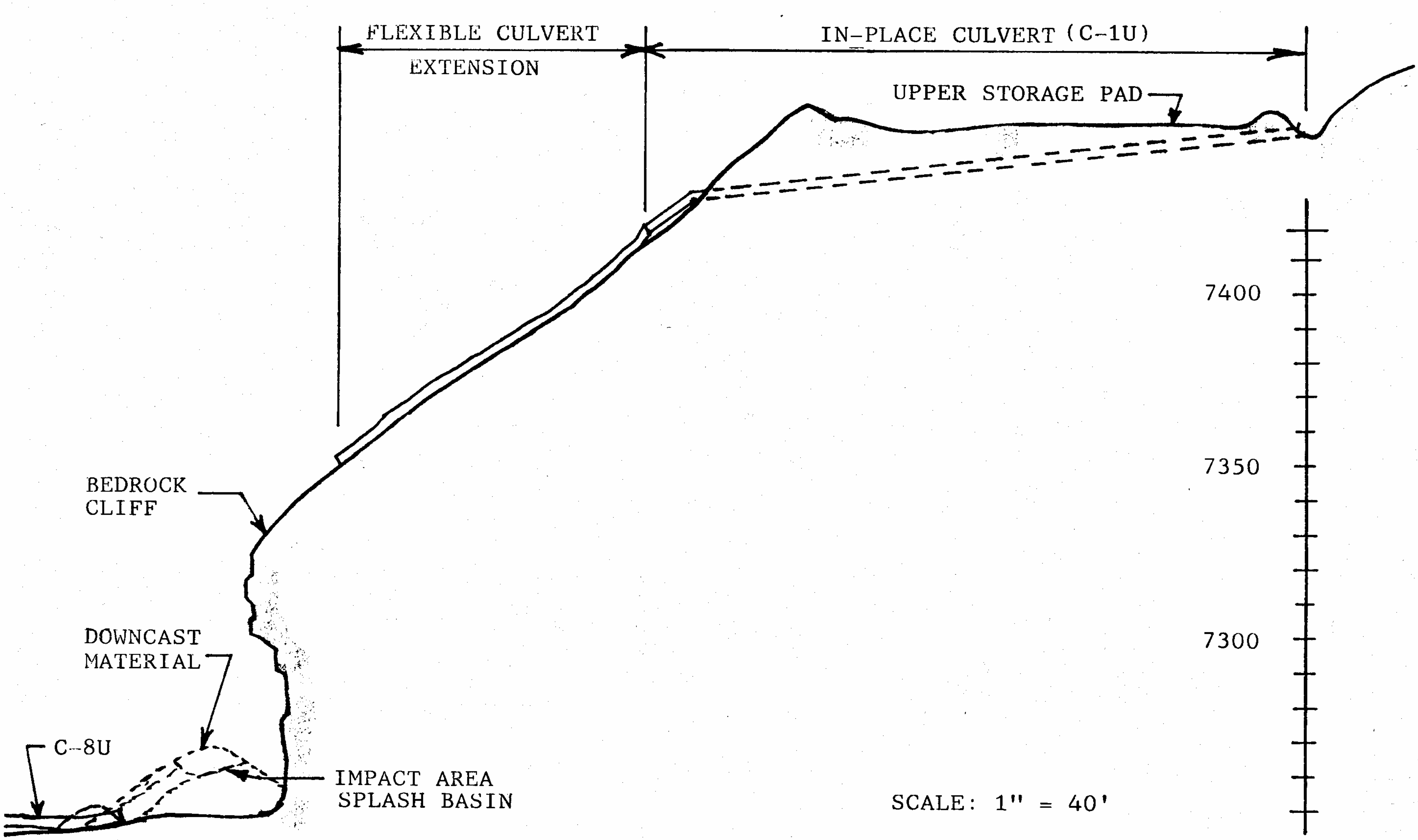


Figure 7-8 Culvert C-1U - Downslope Profile

Additional Control for Hiawatha Seam Mining

As shown on Plate 7-1C, the out-slope of the proposed Hiawatha Seam portal pad encroaches upon the ephemeral channel between D-1D and D-2D. A 15 in. flexible culvert (C-1D and C-2D) and drainage ditch (D-10D and D-7D), as shown on Plate 7-1C, is installed to convey the drainage from the upper areas of the channel beneath the pad to the coal storage pad below. Installation details are shown in Figures 7-9 (Downspout Structure), 7-10 (Collection Box), 7-11 (Ditch D-10D Cross-Section), 7-12 (Buried Cross Sections), 7-13 (Exposed Section Anchor). Riprap specifications will be adhered to as specified in Table 7-24 and Table 7-5.

Prior to September 1995, the flexible culvert was used to convey the drainage the entire length of the slope. A storm event which exceeded the design peak flow of the culvert destroyed a section of the flexible culvert from the uppermost belt tower below the coal storage bin to the coal processing pad. To reduce maintenance, this section will be replaced by a drainage channel as shown in Figure 7-11 and on Plate 7-1C.

In 1998, the lower portion of the flexible culvert was ceased to function and has resulted in continued high maintenance. To reduce maintenance, Ditch D-7D will be extended to carry the runoff currently flowing through Culvert C-2D. This portion of the channel will be riprapped in accordance with Table 7-24. Since the channel slope in this area (49%) does not exceed the design slope for ditch D-7D (55%), the existing design for ditch D-7D will be adequate.

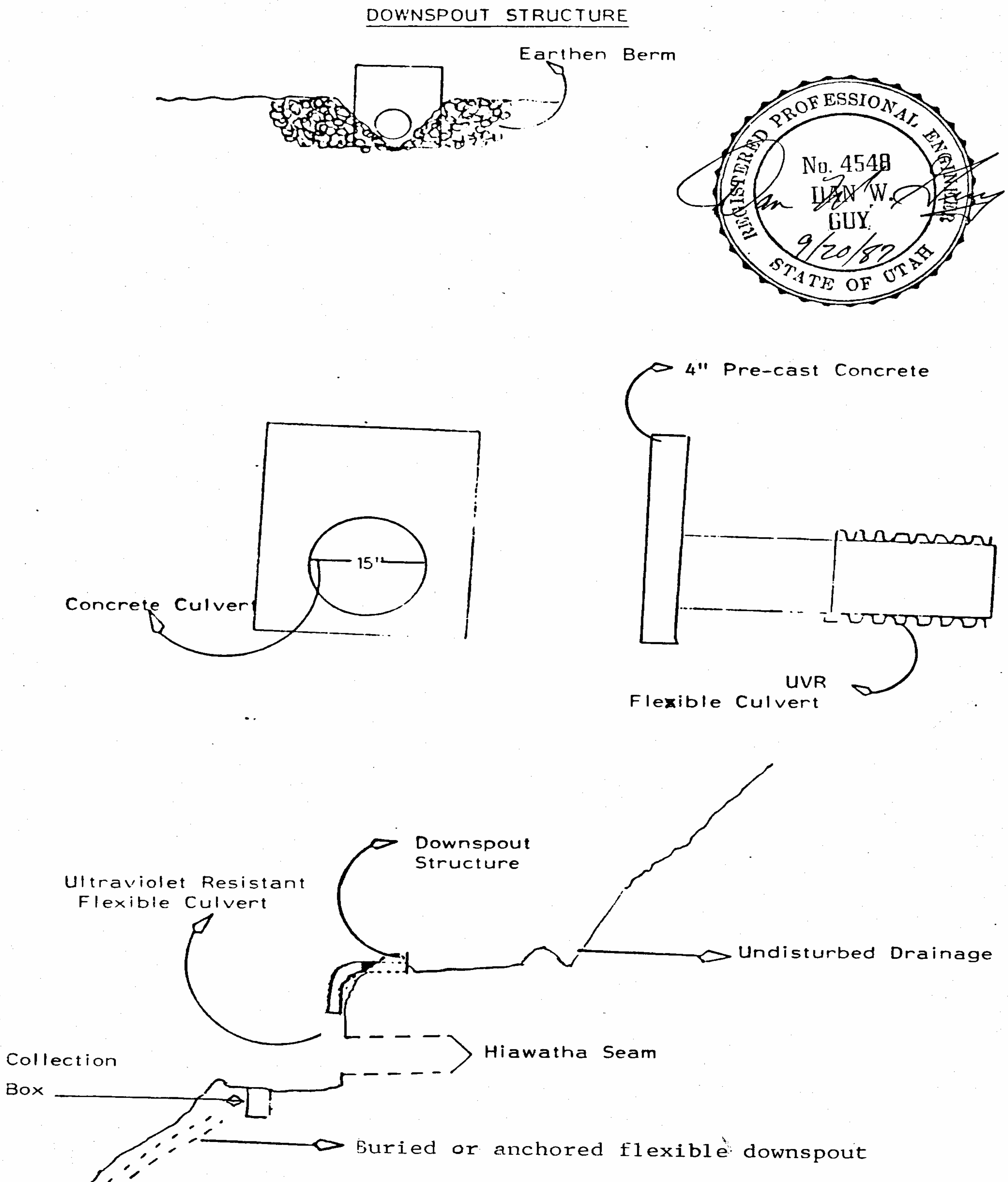


Figure 7-9 Downspout Structure

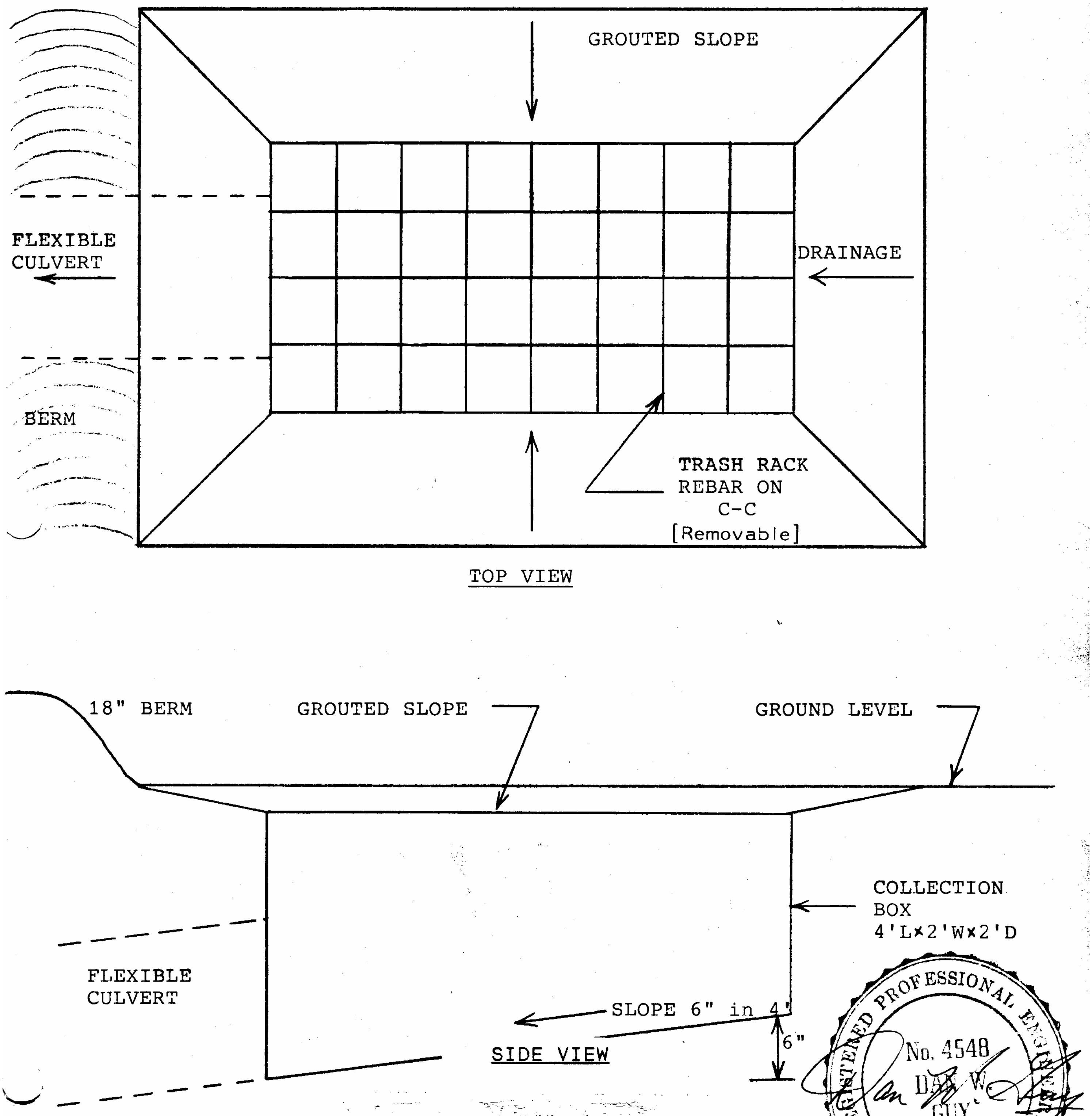


Figure 7-10 Collection Box

REGISTERED PROFESSIONAL ENGINEER
No. 4548
DAN W. GUY
9/14/87
STATE OF UTAH

Ditch D-10D

Typical Cross-Section

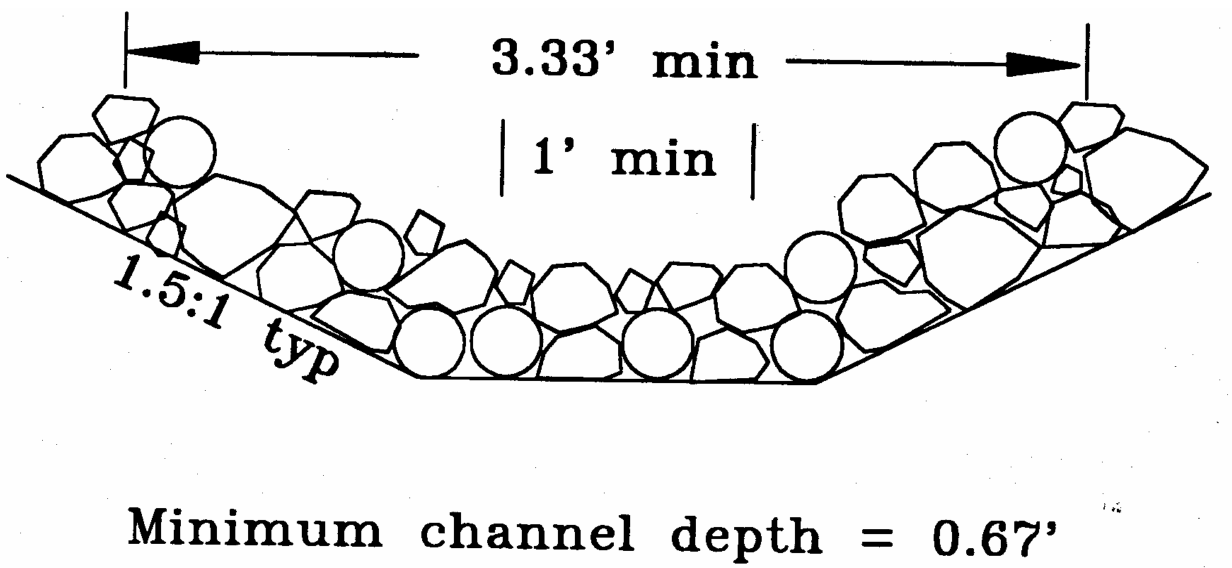
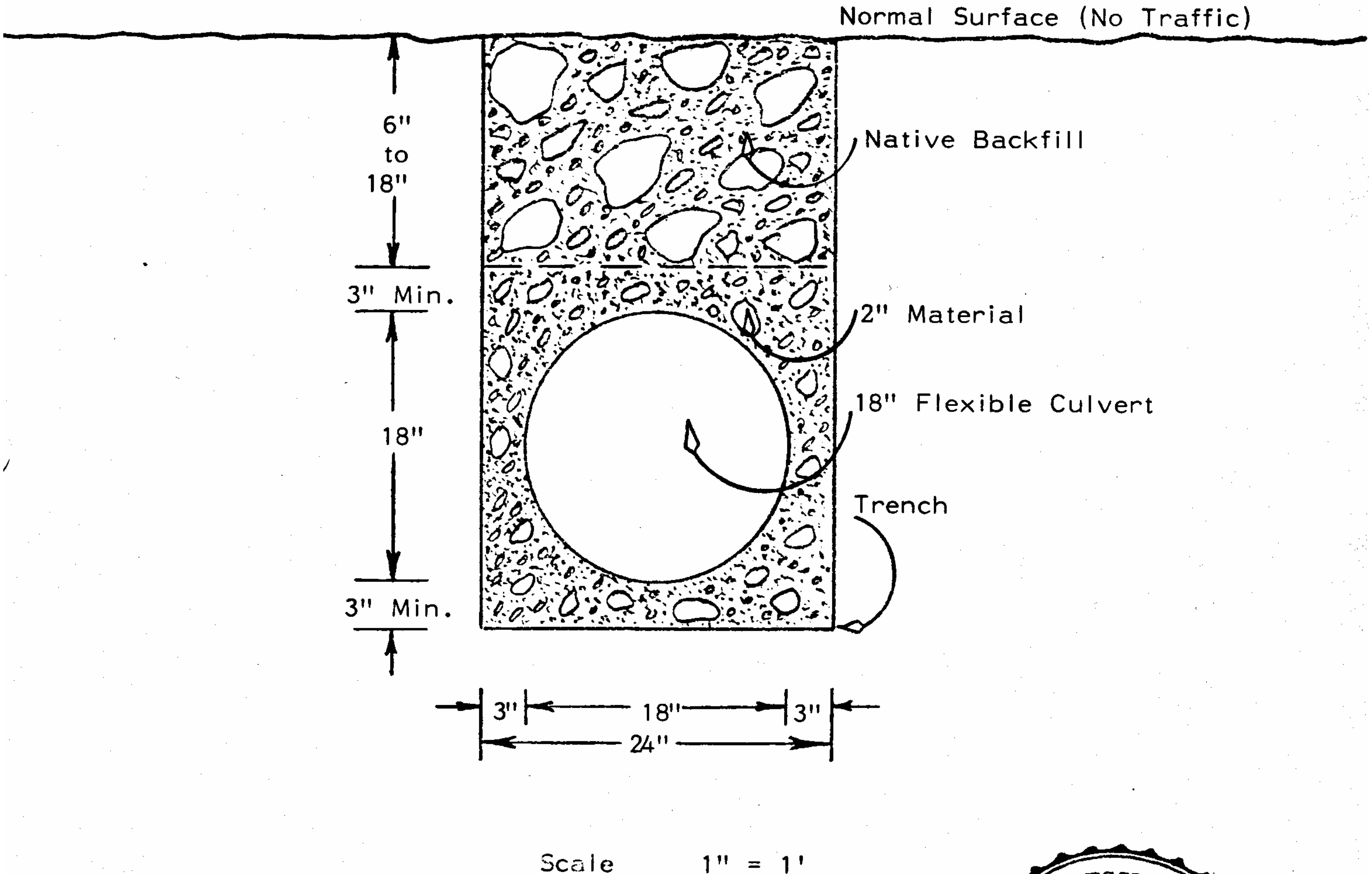


Figure 7-11 Ditch D-10D Cross-Section

Cross-Section of

Buried Flexible Culvert



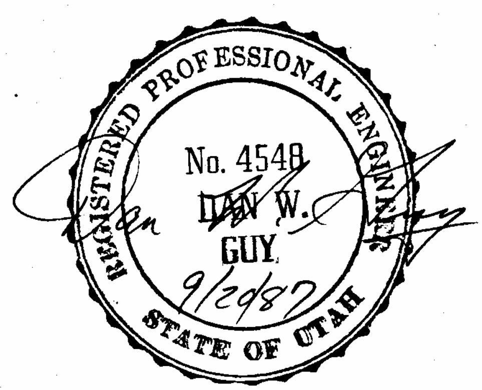


Figure 7-12 Buried Flexible Culvert

Typical Anchor for

Exposed Flexible Culvert

Note: In all areas where the flexible culvert is not buried, it will be anchored per this typical.

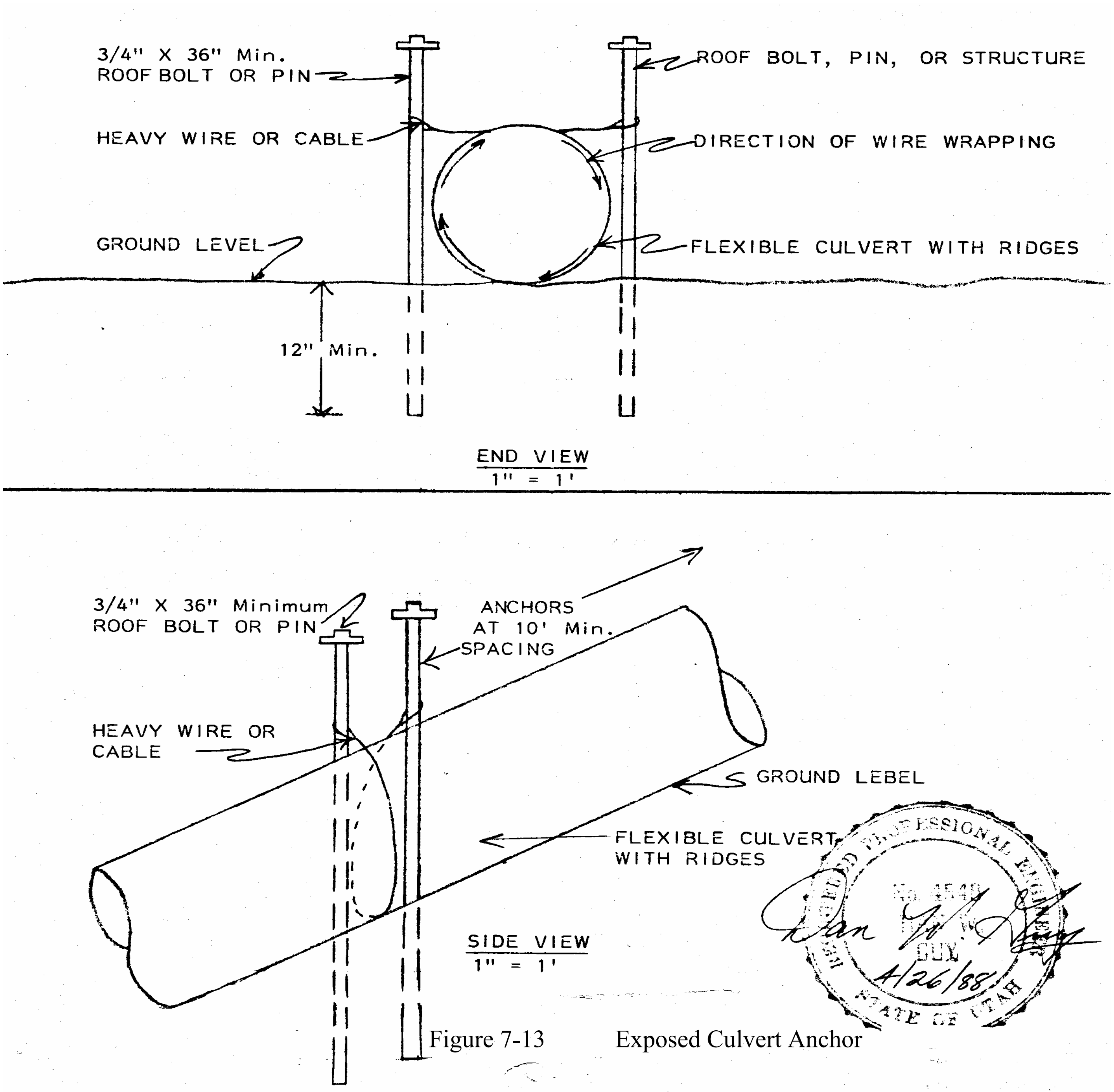


Figure 7-13 Exposed Culvert Anchor

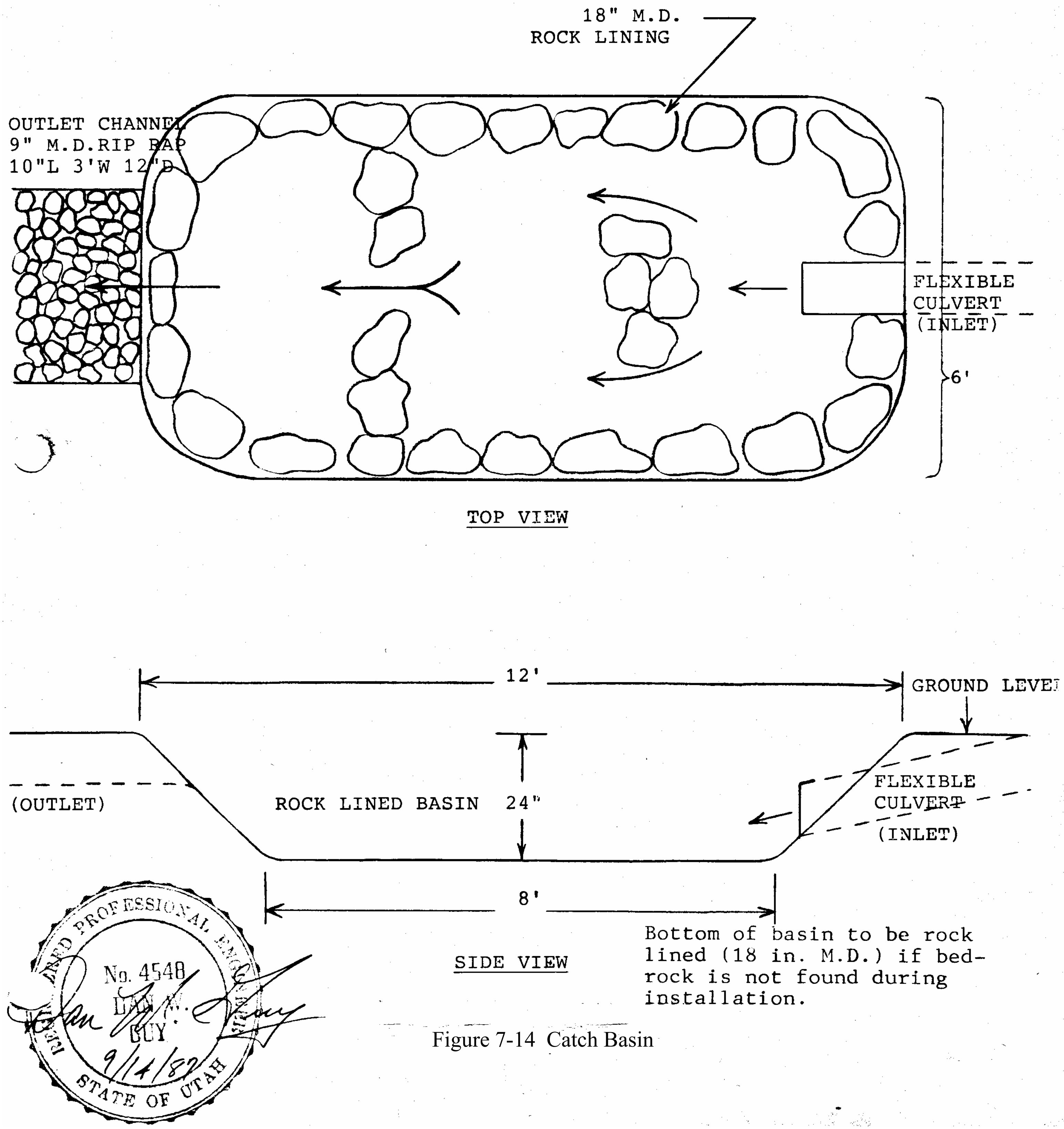


Figure 7-14 Catch Basin

The drainage channel is protected by 4 in. M.D. riprap. When the drainage reaches the Coal Processing pad, it will be conveyed into the Ditch D-7D, which will contain 6 in. M.D. riprap (Plate 7-1C). Ditch designs are shown in Appendix 7-G.

The ditch in this area has been measured, and a typical post-mining section is shown in Appendix 7-H as cross-section RC-3. The ditch profile is shown on Plate 7-8A as Profile RC-3.

DRAINAGE CONTROL SYSTEM BEAR CANYON NO. 1 MINE LOWER SEAM PORTAL AREA

a. Upper Pad. Drainage from the disturbed area on the upper pad from the sub-station to culvert C-1D, will continue to flow into culvert C-1D, as approved; the outlet location of the flexible culvert was moved approx 20 ft to the west of the original location to direct runoff onto the rock ledge above the Lower Seam (Hiawatha) portals; water then flows over the rock ledge to the portal pad below;

b. Portal Pad. The northeast corner of the bin is bermed a min of 30 in. high over to the highwall. Runoff water from the upper pad flows into Ditch D-10D. Runoff from under the bin flows into a collection box at the edge of the portal pad area; the pad is sloped to flow to the box;

c. Flexible Culvert. The collection box at the portal pad discharges into a 15 in. flexible culvert, which discharges into Ditch D-10D adjacent to the uppermost conveyor support;

d. Conveyor Support Area and Slope. Ditch D-10D is constructed to weave across this area as shown on Plate l7-1C until it reaches the Coal Processing Pad area, where it drains into the lower flexible culvert.

e. Coal Processing Pad. This pad is also sloped to drain to the culvert; water is then conveyed down to the lower (Lump Coal) pad area;

f. Lump Coal Pad. The flexible culvert parallels the conveyor down to the lump coal bin, passes beneath the bin supports, and empties into a catch basin/energy dissipater just south of the bin; runoff then flows south into ditch D-7D and passes into Sediment Pond "A."

Drainage is shown on Plate 7-1. Detailed drawings of the various drainage controls are shown in the attached typical details.

Ditch D-7D, Catch Basin

In order to reduce sediment loading at the low-sloped portion of ditch D-7D a catch basin will be constructed at the north west corner of the bath house and shop. This basin will catch sediment, which has previously tended to block flow in the ditch behind the bathhouse and shop. The basin will not be designed for full containment but will be installed to provide this additional control. The basin is easily accessed and will be maintained routinely as required. See Plate 7-1C.

Tipple Wash Drainage 1992

Water is directed down the slope under the Tipple during cleaning. To control erosion during this washing, a drainage channel (D-11D) will be riprapped and grouted down the slope as shown on Plate 7-1C. Grouting is required due to the steepness of the slope (see calcs App. 7-G). Drainage will then be directed into an existing culvert (C-10D) that crosses the Coal Storage Pad. This culvert was installed during construction of the pad for possible future use. From the outlet the flow will pass down another ditch, D-12D, and into ditch D-3D.

This controlled source of water is estimated at 50 gpm (0.11 cfs). Culvert and channel designs were made using 0.25 cfs (112 gpm). This will result in a conservative design. Ditch D-3D is designed for a flow of 2.36 cfs (see App. 7-G). The Tipple will not be washed during a hydrologic event, so the design flow and the wash flow will not be combined. No alterations to downstream drainage control structures are required and none are proposed.

Shower House Drainage Control and Stream Protection

Due to the narrow nature of Bear Canyon, disturbance for the shower house structure and parking lot will encroach upon the 100 ft buffer zone of Bear Creek. Co-Op requests authorization from the division for operation within this zone. Bear Creek will be protected from disturbed runoff or sediment loading with berms placed along the lower edge of the disturbed area. Ditch D-9D (Plate 7-1B) will convey all disturbed runoff from the area to sediment pond "C", preventing disturbed runoff from entering Bear Creek. Stream Buffer Zone signs will be placed at the edge of the disturbed area as shown on Plates 5-2 in accordance with R645-301-521.600.

Access to the area will require the crossing of Bear Creek. A 60" culvert (C-14U) will be installed according to the stream alteration permit shown in Appendix 7-O. The only other impact to Bear Creek will be the riprapping of the outlet to sediment pond "C", also included in Appendix 7-O. Temporary sediment control structures will be placed in Bear Creek during the installation of C-14U to trap sediment resulting from the culvert installation. Reclamation of C-14U will be performed in accordance with R645-301-760.

Tank Seam Portal Pad & Access Road

Due to the remote location of the Tank Seam Portal Pad with respect to the sedimentation ponds, drainage from the portal area will be controlled using a silt fence as shown on Plate 7-1E (BTCA Area "U”). The area, approx. 0.25 acres, will be used only for mine access and portal structures, and will not be used for storage. Ditch D-14D will convey the drainage from AU-4A, which includes the portal pad, to culvert C-11D. A silt fence will be located prior to the inlet of C-11D.

Runoff will be conveyed past the Tank Seam Access Road via ditches and culverts (See Plates 7-1C and 7-1E). Runoff from the disturbed slopes and cut faces along the access road, designated as BTCA areas "H" through "T", will be treated with silt fences and/or erosion control matting as described in Appendix 7-K.

Culvert outlets will be located in places where the outlet conditions meet or exceed the minimum requirements, which are shown in Appendix 7-G. Table 7-25 shows the actual outlet conditions which will exist for each culvert. These conditions reflect existing conditions within the premining channels at the points where the culvert outlets will be located. The culverts along the road will not require any disturbance at the outlets, but will use the premining conditions, which exist.

The reclaimed channel designs for the Tank Seam Access Road are described in Appendix 7-H, and reflect the pre-mining channel conditions. Pre-mining channels consisted of eroded channels passing over large boulders embedded into the soil and/or bedrock.

Reclamation activities for the channels will involve excavating the channel back to the pre-mining configuration. The majority of the boulders in the pre-mining channels will remain as markers, which can be excavated back to. Photographs of the pre-mining channels are contained in Appendix 7-H, and the profiles on Plate 7-8C reflect the pre-mining profiles and descriptions.

Wild Horse Ridge Access

The portal pad for the Bear Canyon No. 3 Mine will drain into Sediment Pond "D". For the remaining disturbed areas associated with the Wild Horse Ridge access road and conveyor belt, runoff will be controlled using alternate (ASCA) treatments. See Plates 7-1F and 7-1G for division structures and ASCA areas (BTCA Area "V", "W", "X" and "Y").

Runoff control for these ASCA areas are described in Appendix 7-K, and will consist of silt fences, erosion control matting and/or catch basins as described in Appendix 7-K and shown on Plates 7-1F and 7-1G. ASCA areas under the conveyor belt will be protected by a pan structure on the conveyor belt is described in Appendix 7-K.

Designs for the ditches and culverts associated with this area are included in Appendix 7-G and summarized in Tables 7-24 and 7-28.

The reclaimed channel designs for the Wild Horse Ridge Area are described in Appendix 7-H and R645-301-760.

Area AD-8 Drainage, 1993

In 1993, the inlet to culvert C-7D failed, resulting in NOV 93-35-6-1. In order to eliminate the maintenance problems with culvert C-7D, the south end of drainage area AD-8, the coal storage pad, will be regraded to allow the drainage to flow into ditch D-7D below the fans shown on Plate 2-4C. At this point, the storage pad is level with D-7D, allowing drainage to easily flow into the ditch. The berm around the coal storage pad will prevent drainage over the edge of the pad and direct the flow toward ditch D-7D. The point at which the storage pad intersects D-7D is outside of the angle of repose of the coal pile, and the ditch will not be plugged by coal spillage. A catch basin exists just below this point which will trap any coal fines which may be washed into the drainage, protecting ditch D-7D below this point.

Ditch D-8D Water Bar

In 1996, Co-Op observed that erosion problems existed which were associated with the water bar conveying runoff from Ditch D-8D to the inlet of Sediment Pond "B" as a result of water associated with the Water Truck. In order to eliminate these problems, the water bar and associated channel will be grouted using an 8" concrete slab. This will prevent the channel from eroding. Figure 7-15 shows a typical cross-section of the concrete crossing. A steel bridge structure and swell provides vehicle crossing as shown in the figure. The bridge is designed so that the water bar design cross-section is maintained passing under it.

<u>Culvert C-40U</u>

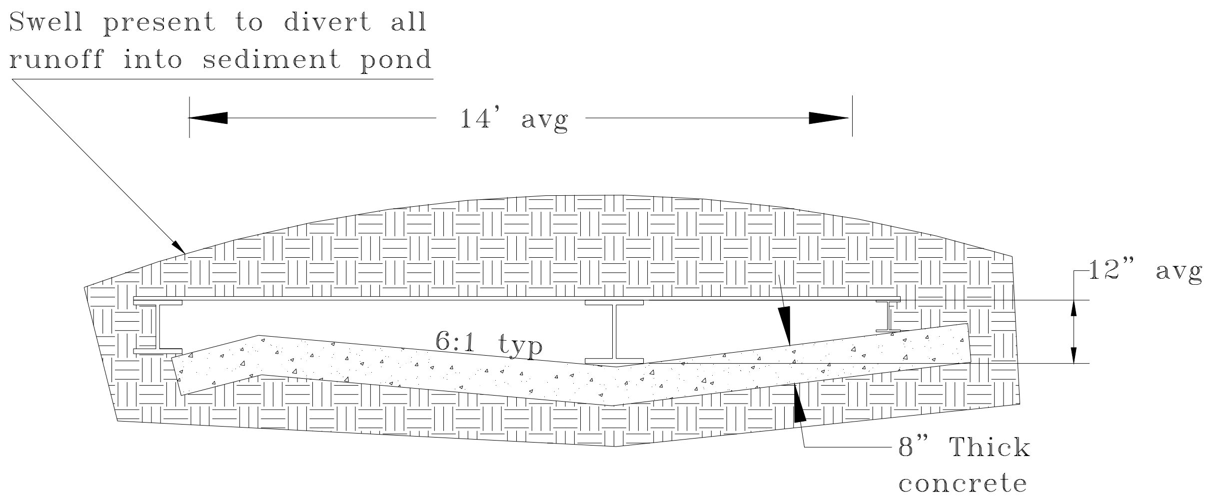
A trash and a debris clean out basin will be placed at the entrance to culvert C-40U. Additionally while constructing the Tank Seam Portal C.W. Mining will investigate other methods that can be incorporated to reduce the possible culvert C-40U becoming plugged by debris.

Additional Sediment Control

In order to reduce potential impacts form sediment, silt fences shall be installed as shown in Figure 7-7. Silt fence locations are noted on Plates 7-1.

Figure 7-15 Ditch D-8D Water Bar Concrete Structure

Typical Cross-Section



Minimum Channel Depth = 0.67'
Minimum Required Depth =0.33'

R645-301-744 Discharge Structures

See R645-301-742.220.

R645-301-760 Reclamation Hydrology

Post-Mining Rehabilitation

Upon completion of mining activities all diversion structures (ditches, culverts, ponds) shall be removed and reclaimed as close to the original configurations as possible. Sequencing of this reclamation shall be from the highest points in elevation to the lowest ones. In addition, the lower disturbed area collection ditches and the sedimentation ponds shall not be removed until the reclaimed areas have stabilized.

The Haul Road and No. 3 Mine Access Road will remain in place to facilitate the recreational Post-Mining Land use described in Ch. 4. All disturbed areas adjacent to these roads will be reclaimed as described in Ch. 3.

Restoration of Natural Channels

There are eighteen channels in addition to Bear Creek whose drainages have been disturbed by mining activities. Reclamation of all but two of these channels shall include placement of naturally configured channels. Design of these channels is provided in Appendix 7-H. Plates 7-7 and 7-8 show the locations, typical cross-sections and profiles of these channels upon reclamation, with the exception of channels RC-TS1 through RC-TS6. Table 7-27 contains a summary of the reclaimed channel parameters. The remaining two channels will be culverted to allow drainage to cross the Haul Road (RCC-2 and RCC-3). Additional culverts will remain in place on Bear Creek and along the No. 3 Mine Access Road. Plates 7-7 show the location of these culverts. The designs are included in Appendix 7-H. Table 7-28 summarizes the designs.

Table 7-26 Characteristics of Proposed Reclaimed Channels

Channel	Bottom Width (ft)	Side Slopes	Depth (ft)	Lining
RC-1	6	1.5:1	1.5	D50 = 6"
RC-2	3	2:1	1.5	D50 = 9"
RC-3	3	2:1	1.5	D50 = 9"
RC-4	4	2:1	1.5	D50 = 6"
RC-5	1.5	2:1	1.5	D50 = 6"
RC-6	2	2:1	1.5	D50 = 6"
RC-7	6	2:1	4	D50 = 24"
RC-8	8	2:1	2.5	D50 = 24"
RC-9	7	2:1	3	D50 = 24"
RC-10	6	1.5:1	6	D50 = 24"
RC-11	2	2:1	1.5	D50 = 6"
RC-12	1	2:1	2	D50 = 6"
RC-TS1	10'-12' Avg.	1:1 Typ	8'-9' Avg.	12"-72" Rock
RC-TS2	12' Avg.	1.5:1 Typ	4' Avg.	Bedrock 12"-72" Rock
RC-TS3	6' Avg.	1.5:1 Typ	4' Avg.	12"-60" Rock
RC-TS4	15' Avg.	1:1 Typ	4' Avg.	8"-36" Rock
RC-TS5	4'-6' Avg.	1.5:1 Typ	2'-6' Avg.	18"-48" Rock
RC-TS6	20' Avg.	1:1 Typ	2'-5' Avg.	Bedrock 18"-48" Rock

Table 7-27 Summary of Post-mining Drainage Ditches

Channel	Bottom Width (ft)	Top Width (ft)	Side Slopes	Depth (ft)	Lining
RC-RD1	0.0	6	2:1	1.5	Soil
RC-RD2	0.0	8	2:1	2.0	D50 = 6"
RC-RD3	0.0	6	2:1	1.5	Soil
RC-RD4	0.0	8	2:1	2.0	D50 = 6"
RC-RD5	5.0	14	3:1	1.5	Soil
RC-RD6	0.0	6	2:1	1.5	Soil
RC-RD7	0.0	6	2:1	1.5	Soil
RC-RD8	0.0	7	2:1	1.75	D50 = 6"
RC-RD9	0.0	12	3:1	2.0	D50 = 6"
RC-RD10	0.0	6	2:1	1.5	Soil
RC-RD11	0.0	5	2:1	1.25	Soil
RC-RD12	0.0	6	2:1	1.5	D50 = 3"
RC-RD13	0.0	6	2:1	1.5	D50 = 3"
RC-RD14	0.0	8	2:1	2.0	Bedrock
RC-RD15	0.0	5	2:1	1.25	Soil
RC-RD16	2.0	7	2:1	1.25	Soil
RC-BP1	0	5	3:1, 1:1	1.24	Soil

Note: See Appendix 7-H, pg. 130 for a discussion on channel RC-BP1.

Table 7-28 Summary of Post-mining Culverts

Culvert	Contributing Watershed	Dia. (in)	Culvert Type	Slope (ft/ft)	Outlet Conditions
RCC-1	Road Drainage	15	CMP	0.06	Soil
RCC-2	WS-8	24	CMP	0.04	D_{50} = 6"
RCC-3	WS-9, WS-10	18	CMP	0.10	D_{50} = 12"
RCC-4	Bear Canyon	84	CMP	0.06	D_{50} = 48"
RCC-5	WS-2, WS-3 WS-3A	30	CMP	0.10	D_{50} = 6"
RCC-6	WS-12, WS-13	20	CMP	0.06	D_{50} = 6"
RCC-7	Right Fork Lower	36	CMP	0.06	D_{50} = 36"
RCC-8	WS-14, WS-16	15	CMP	0.06	D_{50} = 6"
RCC-9	WS-16	15	CMP	0.06	D_{50} = 6"
RCC-10	Right Fork Right	30	CMP	0.06	D_{50} = 24"
RCC-11	WS-19, WS-20	15	CMP	0.06	D_{50} = 6"

Channels RC-TS1 through RC-TS6 refer to the channels disturbed by the Tank Seam Access Road. Appendix 7-H and Plate 7-8C provide documentation of the premining channels. This documentation will be used to restore the postmining channels to the premining conditions. Information in Table 7-27 also represents the observed premining channel parameters.

Bear Creek Channel Reclamation

Upon final abandonment and reclamation the culverted sections of Bear Creek will be reclaimed as follows:

1. Large track mounted excavators will be used in conjunction with a small backhoe and crawler tractor to remove the 60 in diameter culvert and to regrade the opposing banks on approximately a 3 to 1 slope to facilitate revegetation and to enhance the establishment of a riparian zone.

2. The recontoured channel will be riprapped as discussed in Appendix 7-H.

3. Two culverts, identified as RCC-4, shown on Plate 7-7 and Plates 3-2, will remain in place for postmining land use. Designs for these culverts are included in Appendix 7-H.

Sedimentation Ponds Reclamation

Sediment ponds "A", "B" and "C" will be the last structures to be removed. Each pond will be maintained until revegetation is established on all reclaimed lands. When revegetation has been established, drainage ditches conveying water to the Pond will be removed, allowing runoff to drain to Bear Creek. The ponds will then be decanted and allowed to dry. The sediment ponds will then be regraded. Reclamation, redistribution of soils, is discussed in R645-301-242. Revegetation is addressed in R645-301-341. Seed mix is included in R645-301-341. Silt fences will be installed along the creek side of the disturbance on each pond and maintained until vegetation is re-established, at which time the silt fences will be removed. Cross sections of reclamation channels are found in Appendix 7-H. Decant culverts will be salvaged if possible. Otherwise, they will be disposed of in an approved landfill.

Sediment Pond “D”, due to its remote location, will be reclaimed during the initial reclamation of the NO. 3 Mine Portal Pad. ASCA treatment will be used for this reclaimed area as described in Appendix 7-K. See Plates 3-2 for designated Post-Mining ASCA areas.

Post-Mining Water Quality Standards

During the reclamation bond liability, water monitoring will be conducted to assess the potential for water pollution. Prior to final bond release, an assessment of the water quality information will be made to assess any impacts to springs or surface water, to demonstrate that disturbance to the hydrologic balance in the permit and adjacent areas have been minimized, and to show that the water quality and quantity are suitable for the post-mining land uses.

Water quality standards and effluent limitations for chemical constituents will be based on a comparison to the background levels measured and demonstrated by the baseline water quality data.

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